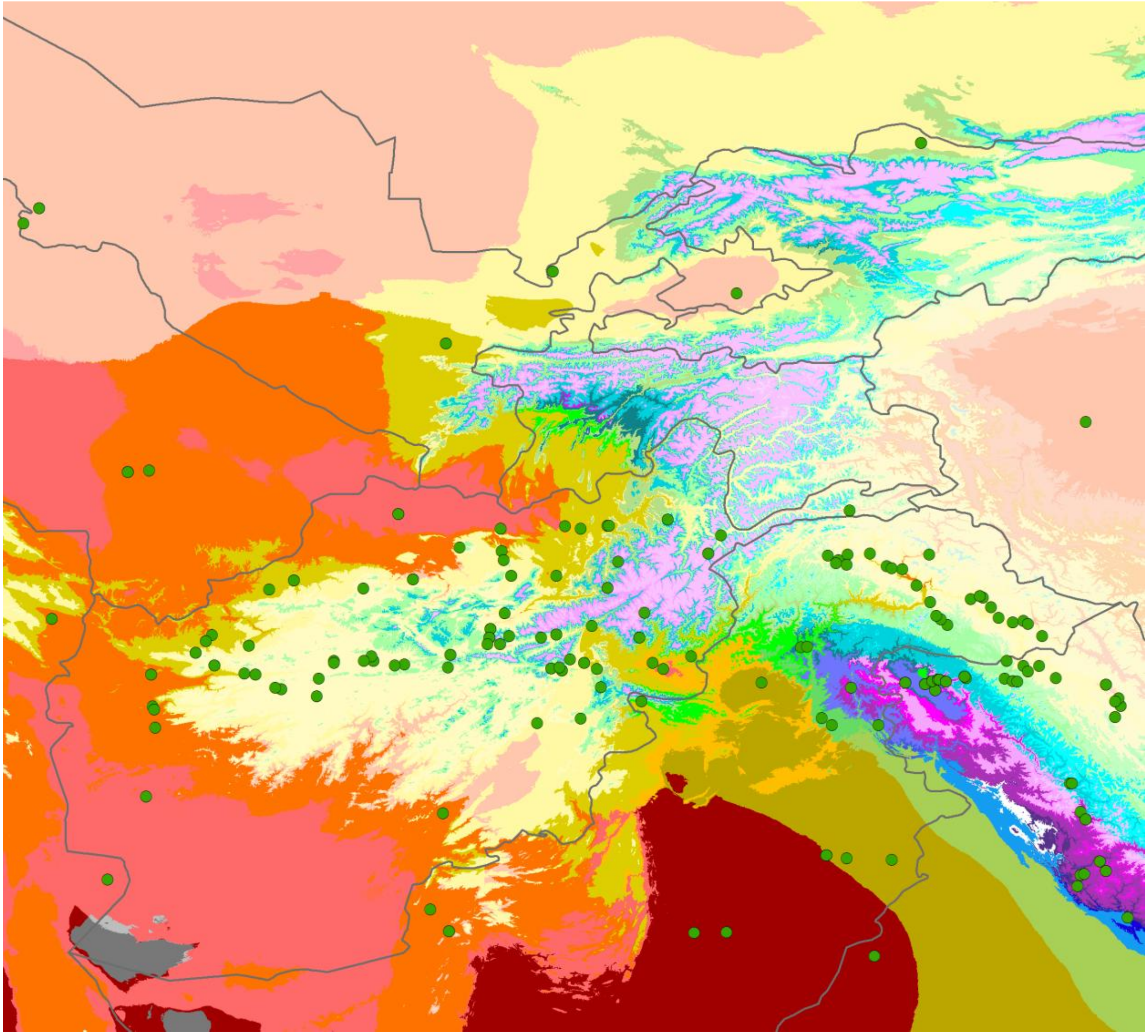
Climatic and Soil Datasets for the ICARDA Wheat Genetic Resource Collections of the Eurasia Region

Explanatory Notes



Agroclimatic zones of Afghanistan and parts of Central Asia, Pakistan, Iran and China with accession sites

E. De Pauw

2008
Technical Note
ICARDA GIS Unit

Table of Contents

1. INTRODUCTION

In 2003, as a deliverable of the BMZ-funded project "Exploration of genetic resources collections at ICARDA for adaptation to climate change", a new eco-climatic database was established consisting of GIS layers of climatic parameters at 1 km resolution, covering the entire CWANA region.

The CWANA region encompasses the following countries/geographical entities:

- Africa: Morocco/ Algeria/ Tunisia/ Libya/ Egypt/ Mauritania/ Western Sahara/ Sudan/ Eritrea/ Ethiopia/ Somalia/Djibouti
- Asia: Turkey/ Syria/ Jordan/ Israel/ Gaza/ West Bank/ Iraq/ Iran/ Georgia/ Armenia/ Azerbajjan/ Saudi Arabia/ Kuwait/ Oman/ Yemen/ Bahrain/ Qatar/ UAE/ Afghanistan/ Pakistan/ Kazakhstan/ Turkmenistan/ Uzbekistan/ Kyrgyzstan/ Tajikistan

This database has made it possible to characterize the sites within CWANA of the wheat and barley genetic resource collections of ICARDA in terms of a wide range of basic and derived ecoclimatic variables and assisted in the evaluation of the climatic stress tolerance of different accessions.

In 2005 the Genetic Resources Unit at ICARDA requested the GIS Unit to expand this database to Eurasia covering Europe and most of Asia, with the exception of Thailand, Indonesia, and Vietnam, as there were no collection sites in these countries. Moreover it was agreed that soil parameters would be a useful addition to the database.

This report describes the methods used to generate the climatic and soil database and explains the meaning of the climatic and soil characteristics of the accession sites in this region, as presented in the tables of Chapter 3 and the maps of Annex 1.

2. METHODS

2.1. General

Recent advances in GIS technology have increased map resolutions to scales sufficient for the detailed climatic characterization of georeferenced accession sites. The characterization was undertaken by converting a region-wide database of point meteorological station data into 'climate surfaces' with 1 km resolution for the entire study area. The climate 'surfaces' are raster maps in which specific climatic variables, such as precipitation, temperature, potential evapotranspiration, are presented as continuous fields. Using formulas and models these 'basic' climate surfaces were combined into 'derived surfaces' of various ecoclimatic classifications and indices. Data sources and methods for generating the climate surfaces are explained in sections 2.2, 2.3 and 2.4.

The basis for the soil layers is the FAO Digital Soil Map of the World at 1:5,000,000 scale. How these layers were obtained is explained in section 2.5.

2.2. Climatic data and sources

All data are monthly averages for different time periods, but with a minimum of 20 years in the case of precipitation and 5 years in the case of temperature. Record length is variable for different stations. The main sources were international, such as the Food and Agriculture Organization of the United Nations and the National Climate Data Center of the US (NCDC). For some countries, such as Iran, Russia and the Central Asia and Caucasus countries the data came from national archives.
All sources are listed by country and climatic variable (precipitation, PET, maximum and minimum temperature) in the tables of Annex 3.

2.3. Basic climate surfaces

The 'thin-plate smoothing spline' method of Hutchinson (1995), as implemented in the ANUSPLIN software (Hutchinson, 2000), was used to convert the station-based climatic database into 'climate surfaces'. The Hutchinson method is a smoothing interpolation technique in which the degree of smoothness of the fitted function is determined automatically from the data by minimizing a measure of the predictive error of the fitted surface, as given by the generalized cross-validation (Hutchinson, 2000).

Three independent spline variables were used, *latitude, longitude* and *altitude*. The latter was input to the model in the form of a DEM ASCII grid file. The DEM used to generate the climate surfaces was the GTOPO30 DEM with 30 arc-second (approximately 1 km) resolution. Parameter estimation was undertaken over a regular grid with the same dimensions and resolution as the user-provided DEM. In order to automate the process of climate surface generation, which is rather cumbersome, an auxiliary software CLIMAP was used (Pertziger and De Pauw, 2002). This Excel-based software provides a user-friendly interface for running ANUSPLIN and for generating derived surfaces using CLIMAP-provided models.

Using above procedure, the following basic climatic surfaces were generated with 30 arc-second resolution:

- Mean monthly and annual precipitation totals
- Mean monthly temperature
- Mean maximum temperature

- Mean minimum temperature

2.4. Derived climate surfaces

By applying various transformations on the basic climate surfaces, involving different formulas or iterative calculation procedures, new GIS layers were generated for a more focused agroclimatic characterization of the study area. Depending on the specific climatic theme, the operations used to generate new layers were either elementary raster calculations on the existing basic climatic layers, or calculations involving a pre-programmed model.
The list of derived climate surfaces generated for the more in-depth agroclimatic characterization of the study area is given below:

- Ratio of Autumn (September-November) to Annual Precipitation
- Ratio of Winter (December to February) to Annual Precipitation
- Ratio of Spring (March to May) to Annual Precipitation
- Ratio of Summer (June to August) to Annual Precipitation
- Monthly and annual potential evapotranspiration
- Monthly and annual aridity index
- Agroclimatic zones
- Length of the moisture-limited growing period
- Length of the temperature-limited growing period
- Length of the moisture- and temperature-limited growing period under rainfed conditions
- Length of the moisture- and temperature-limited growing period under rainfed and irrigated conditions
- Onset of the moisture-limited growing period
- Onset of the temperature-limited growing period
- Onset of the moisture- and temperature-limited growing period (January-June)
- Onset of the moisture- and temperature-limited growing period (July-December)
- End of the moisture-limited growing period
- End of the temperature-limited growing period
- End of the moisture- and temperature-limited growing period (January-July)
- End of the moisture- and temperature-limited growing period (August-December)

The details for the specific transformations undertaken on the basic climate surfaces in order to obtain each of the above climatic themes are explained further. The vast majority of these transformation methods have been published elsewhere, notably in De Pauw (2002), De Pauw et al. (2004a), and De Pauw et al. (2004b), and were implemented with ICARDA's CLIMAP software.

2.4.1. Seasonal precipitation

- Ratio of Autumn (September-November) to Annual Precipitation:

$$\frac{prec_{09} + prec_{10} + prec_{11}}{\sum_{i=1}^{12} prec_i}$$

- Ratio of Winter (December to February) to Annual Precipitation:

$$\frac{prec_{12} + prec_{01} + prec_{02}}{\sum_{i=1}^{12} prec_i}$$

- Ratio of Spring (March to May) to Annual Precipitation:

$$\frac{prec_{03} + prec_{04} + prec_{05}}{\sum_{i=1}^{12} prec_i}$$

- Ratio of Summer (June to August) to Annual Precipitation:

$$\frac{prec_{06} + prec_{07} + prec_{08}}{\sum_{i=1}^{12} prec_i}$$

with i: month number
prec: total precipitation during month i

2.4.2. Potential evapotranspiration

The Penman-Monteith method is the current standard for the calculation of PET according to the formula:

$$PET = W.\ R_n \quad + \quad (1\text{-}W) * f(U) * (e_s - e_a)$$

with W: temperature-related weight factor;
Rn: net radiation in equivalent evaporation (in mm/day)
f(U): wind-related function
(e_s-e_a): difference between saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air;

The full calculation procedure for the Penman-Monteith formula can be found in Allan et al.(1998). PET data calculated according to the Penman-Monteith method (PET_{PM}) were not available for most stations because not all climatic variables were available. For this reason it was necessary to *estimate* PET from data that are commonly available. Given the database, the most feasible option was to establish correlations between PET and temperature. This should work quite well, because in dryland region temperature is the main contributing factor to evapotranspiration. In fact, by establishing a direct relationship between PET and the mean temperature, as in the following example involving many stations from around the world (Fig.1), a high degree of correlation can be established:

$$PET_{PM} = 5.227e^{0.0685Temp} \quad (r^2 = 0.76)$$

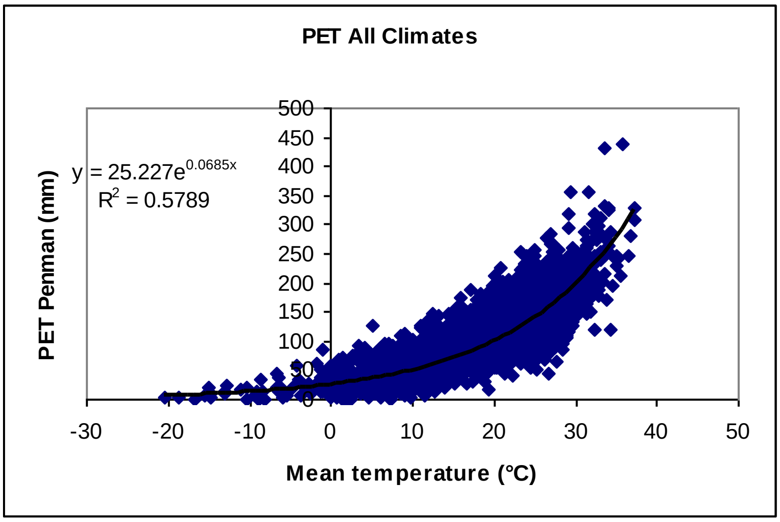


Figure 1. Correlation between PET Penman-Monteith and temperature
(all climates combined)

However, from initial tests it was established that the highest correlations were consistently obtained from a two-step procedure:

- estimate PET from temperature according to the Hargreaves method (PET_{HG});
- estimate PET $_{Penman\text{-}Monteith}$ from $PET_{Hargreaves}$ through regression (Fig. 2).

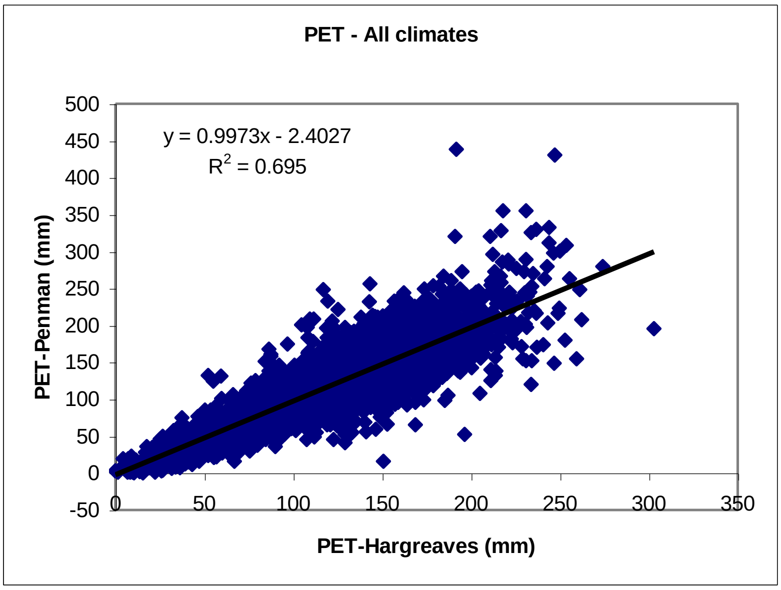


Figure 2. Correlation between PET Penman-Monteith and PET Hargreaves
(all climates combined)

In addition, it was found that if stations are disaggregated according to climatic zones, the two-step approach generally leads to better correlations, and therefore, better estimates of PET_{PM}. This is probably due to the following reasons:

- the intermediate calculation of PET_{HG} allows to incorporate the effect of day length, the degree of continentality, and indirectly, radiation on PET.
- The disaggregation according to climatic zones allows to recognize some more subtle linkages, e.g. between temperature and time at which rainfall occurs (winter or summer),

or temperature and relative humidity (which will be different between temperate and arid/semi-arid climates).

Table 1. Statistical relationships for different climates between PET-Penman/Monteith and PET-Hargreaves differentiated by Köppen climatic zones

Climatic zone		Equations	R^2
Af	tropical rainy climate, humid and warm	$PET_{PM} = 0.512\ PET_{HG} + 56.36$	.153
Am	tropical rainy climate, monsoon type, with moderately dry season	$PET_{PM} = 0.3927\ PET_{HG} + 71.211$	.081
As	tropical rainy climate, savanna climate with summer drought	$PET_{PM} = 0.9848\ PET_{HG} + 36.317$	.391
Aw	tropical rainy climate, savanna climate with winter drought	$PET_{PM} = 0.7761\ PET_{HG} + 29.205$	.317
BS	semi-arid (steppe) climate	$PET_{PM} = 0.9858\ PET_{HG} + 5.413$	.689
BSs	semi-arid (steppe) climate with summer drought	$PET_{PM} = 1.0653\ PET_{HG} - 4.0674$	.793
BSw	semi-arid (steppe) climate with winter drought	$PET_{PM} = 0.9806\ PET_{HG} + 5.8843$	.654
BWs	arid (desert) climate with summer drought	$PET_{PM} = 1.1823\ PET_{HG} - 7.5911$	.818
BWw	arid (desert) climate with winter drought	$PET_{PM} = 1.1149\ PET_{HG} - 10.513$	.745
Cwa	warm temperate rainy climate with winter drought and hot summers	$PET_{PM} = 1.022\ PET_{HG} - 11.579$	.774
Cwb	warm temperate rainy climate with winter drought and warm summers	$PET_{PM} = 0.8526\ PET_{HG} + 5.6015$	.6711
Cwc	warm temperate rainy climate with winter drought and cool summers	$PET_{PM} = 0.78\ PET_{HG} + 7.9992$	.5974
Csa	warm temperate rainy climate with summer drought and hot summers	$PET_{PM} = 1.0704\ PET_{HG} - 9.504$	.876
Csb	warm temperate rainy climate with summer drought and warm summers	$PET_{PM} = 0.9165\ PET_{HG} - 7.2432$	.860
Cfa	warm temperate rainy climate without dry season and hot summers	$PET_{PM} = 0.9429\ PET_{HG} - 5.719$	.805
Cfb	warm temperate rainy climate without dry season and warm summers	$PET_{PM} = 0.8469\ PET_{HG} + 1.3915$	.775
Cfc	warm temperate rainy climate without dry season and cool summers	$PET_{PM} = 0.7257\ PET_{HG} + 5.6185$	.802
Df	continuously humid subarctic climate	$PET_{PM} = 0.8351\ PET_{HG} + 1.6032$	.888
Ds	Subarctic climate with warm summer	$PET_{PM} = 0.9773\ PET_{HG} - 6.3775$	.931
Dw	subarctic climate with cold, dry winter	$PET_{PM} = 0.8307\ PET_{HG} + 4.6389$	.855
E	Arctic climate	$PET_{PM} = 0.8474\ PET_{HG} + 15.338$	.820

The Köppen system of climate classification was found to be particularly suitable for disaggregating the correlations between PET_{PM} and PET_{HG} because it is a system with global applicability and requires only temperature and precipitation data.

Method for disaggregated regressions

From the FAOCLIM 2.0 global climate database monthly PET, calculated by the Penman-Monteith method (FAO, 2002), for 4253 stations from countries with dryland areas were extracted. For each of these stations the Köppen agroclimatic zone was calculated in accordance with the criteria in Debaveye (1985). At the same time the PET was calculated according to the Hargreaves method. This method is based on the combination of temperature data and calculated extraterrestrial radiation and has the following formula (Choisnel, 1992):

$$PET = .0023 * Ra * (T_{mean} + 17.8) * \sqrt{(T_{max} - T_{min})}$$

with: Ra: extraterrestrial radiation ($mm.day^{-1}$)

Correlations were then established between PET-Penman/Monteith (PET_{PM}) and PET-Hargreaves (PET_{HG}) for each major Köppen climatic zone. For dryland and temperate climates with summer drought, good approximations of PET_{PM} are achieved (Table 1).
For stations with these climates the regressions of Table 1 were used. For tropical areas with A-climates, PET was calculated according to the full Penman-Monteith equation using station-specific temperature data, and filling the gaps of relative humidity, wind and radiation data with averages for one-degree grid cells, as obtained from the Atmospheric Science Data Center web site[1].

2.4.3. Agroclimatic zones

The agroclimatic zones were mapped in accordance with the UNESCO classification system for arid zones (UNESCO, 1979). This system is based on three major criteria:

- Moisture regime;
- Winter type
- Summer type

Table 2. Moisture regime, winter type and summer type classes

Moisture regime	Aridity index
Hyper-arid (HA)	< 0.03
Arid (A)	< 0.2
Semi-arid (SA)	< 0.5
Sub-humid (SH)	< 0.7
Humid (H)	<1
Per-humid (PH)	≥ 1

Winter type	Mean Tp. Coldest month
Warm (W)	> 20°C
Mild (M)	> 10°C
Cool (C)	> 0°C
Cold (K)	≤ 0°C

Summer type	Mean Tp. Warmest month
Very warm (VW)	> 30°C
Warm (W)	> 20°C
Mild (M)	> 10°C
Cool (C)	≤ 10°C

In this classification system the *moisture regime* is determined by the ratio of annual rainfall over annual potential evapotranspiration, calculated according to the Penman method (see above). This ratio is also referred to as the *aridity index*. It is therefore particular to this system that in the definition of the moisture regime not only the water supply (precipitation)

[1] http://eosweb.larc.nasa.gov/cgi-bin/sse/subset.cgi?email=e.de-pauw@cgiar.org

is considered, but also the water demand (evapotranspiration). Different (but also the same) classes may thus result depending on the values of the two terms.
The *winter type* is determined by the mean temperature of the coldest month.
The *summer type* is determined by the mean temperature of the warmest month .

Moisture regime, winter type and summer type, were combined in accordance with the classes of Table 2 (see also Fig.3).

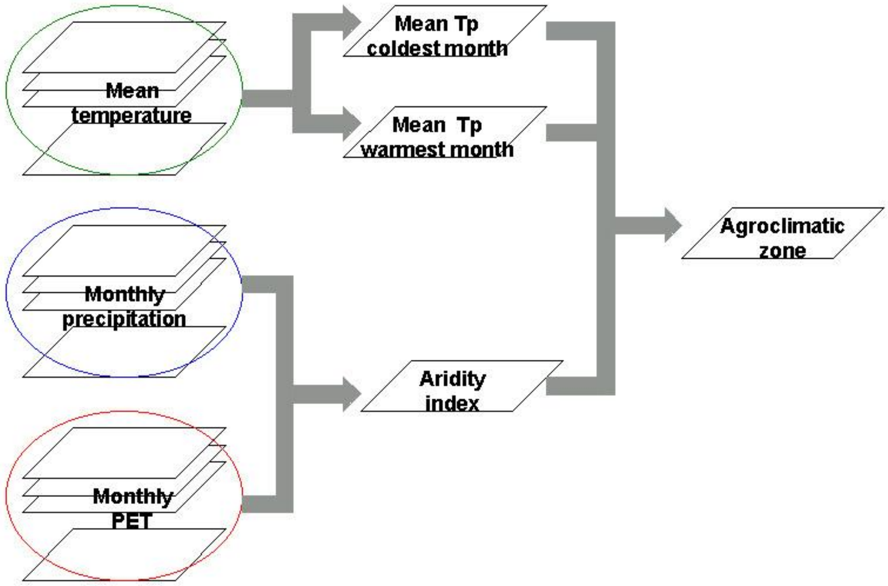


Figure 3. Combination of basic climate surfaces into agroclimatic zones

Originally designed for the differentiation of arid zones, the system has been extended to include also the more humid climates. For example, the moisture regime 'Per-humid' (aridity index >1) has not been defined in the original system, but has been added here in order to provide a better differentiation within the more humid zones not covered by the original UNESCO map.

2.4.4. Growing periods

The climatic growing period is calculated by means of a model developed by the Food and Agriculture Organization of the United Nations (FAO, 1978) to estimate the length of growing period under either moisture-limiting or temperature-limiting conditions, or both. Under rainfed conditions, both moisture and temperature can be limited. Under irrigated conditions, only temperature is to be considered a limiting factor.

The criterion used for the definition of a *moisture-limited growing period* is the ratio of actual evapotranspiration (AET) to potential evapotranspiration (PET). If this ratio for any particular month is higher than a user-defined threshold (in this study 0.5), that month is part of a growing period; if it is not, that month is not part of the growing period. The start date of the growing period is obtained from linear interpolation of the AET/PET ratios between the last month that is part of the growing period, and the first month that is not part of the growing period. The end date, inversely, is obtained by linear interpolation of the AET/PET ratios between the last month that is part of the growing period, and the first one that is not part of the growing period.

The following model for estimating the length of the moisture-limited growing period is an adaptation of the FAO-model.

$$GP_{m,on} = M_{m,on} + NDays_m \frac{Thre_m - R_0}{R_1 - R_0}$$

$$GP_{m,end} = M_{m,end} + NDays2_m \frac{Thre_m - R_{n-1}}{R_n - R_{n-1}}$$

$$LGP_m = GP_{m,en} - GP_{m,on}$$

with: $GP_{m,on}$: onset date of the moisture-limited growing period
$GP_{m,end}$: end date of the moisture-limited growing period
LGP_m: length of moisture-limited growing period
$M_{m,on}$: the number of days from 1 January up to the end of the last month that is not part of the moisture-limited growing period
$M_{m,end}$: the number of days from 1 January up to the end of the month preceding the last month of the moisture-limited growing period
$NDays_m$: number of days in the first month of the moisture-limited growing period
$NDays2_m$: number of days in the last month of the moisture-limited growing period
$Thre_m$: AET/PET threshold for defining a moisture-limited growing period (user-defined; for this study set to 0 .5)
R_0: AET/PET ratio for the month preceding the first month of the moisture-limited growing period;
R_1: AET/PET ratio for the first month of the moisture-limited growing period;
R_{n-1}: AET/PET ratio for the month preceding the last month of the moisture-limited growing period;
R_n: AET/PET ratio for the last month of the moisture-limited growing period.

Similarly the temperature-limited growing period is calculated with reference to a temperature threshold, below which there is no growing period:

$$GP_{t,on} = M_{t,on} + NDays_t \frac{Thre_t - Temp_0}{Temp_1 - Temp_0}$$

$$GP_{t,end} = M_{t,end} + NDays2_t \frac{Thre_t - Temp_{n-1}}{Temp_n - Temp_{n-1}}$$

$$LGP_t = GP_{t,end} - GP_{t,on}$$

with: $GP_{t,on}$: onset date of the temperature-limited growing period
$GP_{t,end}$: end date of the temperature -limited growing period
LGP_m: length of temperature-limited growing period
$M_{t,on}$: the number of days from 1 January up to the end of the last month that is not part of the temperature-limited growing period
$M_{t,end}$: the number of days from 1 January up to the end of the month preceding the last month of the temperature -limited growing period
$NDays_t$: number of days in the first month of the temperature-limited growing period
$NDays2_t$: number of days in the last month of the temperature-limited growing period
$Thre_t$: temperature threshold for defining a temperature-limited growing period (user-defined; for this study set to 5°C)
$Temp_0$: Mean temperature for the month preceding the first month of the temperature-limited growing period;
$Temp_1$: mean temperature for the first month of the moisture-limited growing period;

Temp$_{n-1}$: mean temperature for the month preceding the last month of the moisture-limited growing period;
Temp$_n$: mean temperature for the last month of the moisture-limited growing period.

By combining the moisture-limited growing period with a temperature-limited growing period, length, onset and end of the growing period, limited by both moisture and temperature, can be calculated.

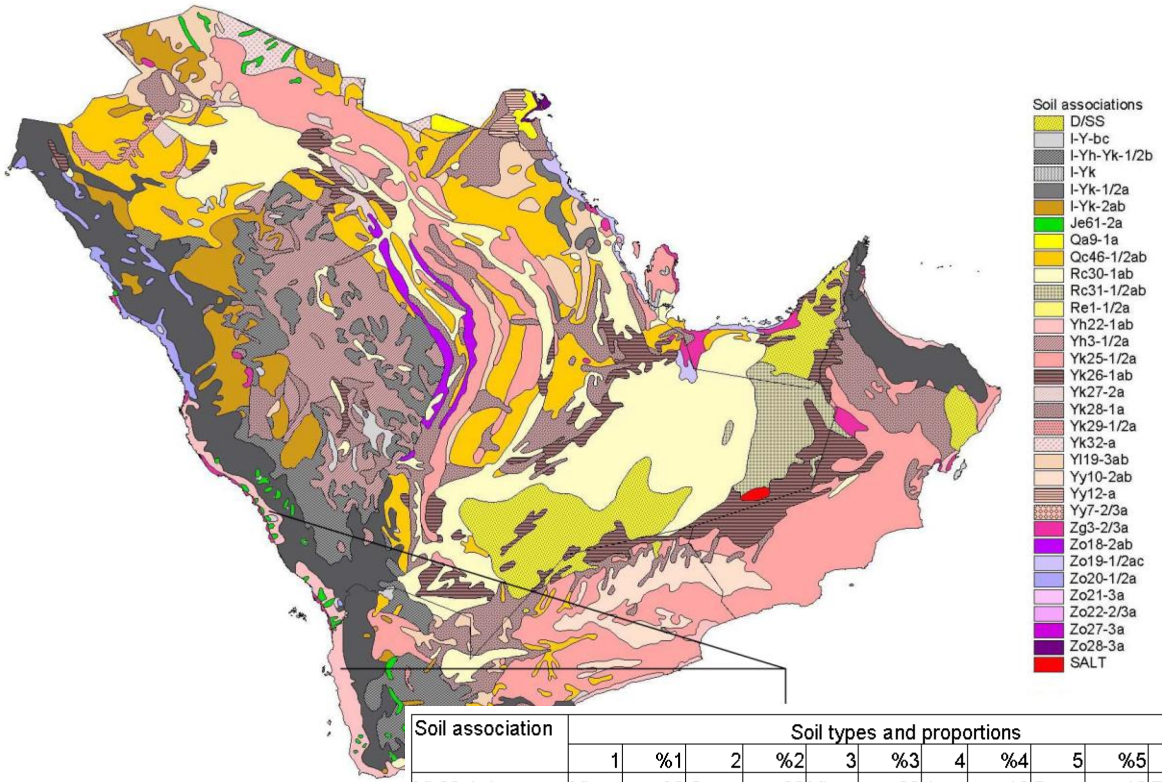
2.5. Derived soil layers

2.5.1. Data source

The data source is the FAO Soil Map of the World. This is a soil classification map with heterogeneous mapping units. While there are homogeneous mapping units (consisting of one soil type), in most cases they are *associations* of different soil types, with a maximum of eight. The legend of the original soil map of the World (FAO, 1974) comprises an estimated 4930 different map units, which consist of soil units or associations of soil units. These soil units are defined through a *classification system* developed by FAO. This classification system comprises 106 soil units, grouped in 26 major soil groups.
The digital version of the global soil map was released in 1995 (FAO, 1995).

2.5.2. Mapping units and soil units

A mapping unit is not the same as a soil unit. Each mapping unit is characterized by a unique combination of component soil types and the proportions each soil type occupies in the soil association.



Soil association	Soil types and proportions											
	1	%1	2	%2	3	%3	4	%4	5	%5	6	%6
Yh22-1ab	Yh	30	Qc	20	Yk	20	Jc	10	Rc	10	Z	10

Figure 4. Composition of a soil association in the Arabian Peninsula (source: FAO, 1995)

To illustrate this important distinction, an extract from the FAO soil map is shown in Figure 4 and the characterization of the component mapping units in Table 1.

Table 3. Main soil associations of the Arabian Peninsula (FAO, 1995)

Soil association	% of the Peninsula	Soil types and proportions											
		1	%1	2	%2	3	%3	4	%4	5	%5	6	%6
D/SS	5.80	DS	100		0		0		0		0		0
I-Y-bc	20.28	I	50	Y	50		0		0		0		0
I-Yh-Yk-1/2b	4.00	I	34	Yh	33	Yk	33		0		0		0
I-Yk	0.04	I	50	Yk	50		0		0		0		0
I-Yk-1/2a	0.26	I	50	Yk	50		0		0		0		0
I-Yk-2ab	2.41	I	50	Yk	50		0		0		0		0
Je61-2a	0.32	Je	90	Zo	10		0		0		0		0
Qa9-1a	0.48	Qa	100		0		0		0		0		0
Qc46-1/2ab	6.51	Qc	50	I	20	Y	20	R	10		0		0
Rc30-1ab	9.33	Rc	50	Qc	20	Yk	20	Z	10		0		0
Rc31-1/2ab	1.23	Rc	70	Z	30		0		0		0		0
Re1-1/2a	0.00	Re	100		0		0		0		0		0
SALT	0.05	ST	100		0		0		0		0		0
Yh22-1ab	4.96	Yh	30	Qc	20	Yk	20	Jc	10	Rc	10	Z	10
Yh3-1/2a	3.74	Yh	70	I	30		0		0		0		0
Yk25-1/2a	10.94	Yk	40	I	20	Yl	20	Jc	10	Z	10		0
Yk26-1ab	3.39	Yk	70	Qc	30		0		0		0		0
Yk27-2a	0.09	Yk	60	Z	30	I	10		0		0		0
Yk28-1a	6.40	Yk	60	Rc	30	I	10		0		0		0
Yk29-1/2a	0.25	Yk	60	Rc	30	Z	10		0		0		0
Yk32-a	8.12	Yk	60	I	20	Yl	20		0		0		0
Yl19-3ab	2.68	Yl	50	I	20	Yk	20	Rc	10				
Yy10-2ab	3.79	Yy	60	I	20	Yk	20		0		0		0
Yy10-2ab	0.37	Yy	60	I	20	Yk	20		0		0		0
Yy12-a	0.54	Yy	60	I	30	Yk	10		0		0		0
Yy7-2/3a	0.05	Yy	50	Yk	20	Zo	20	Jc	10		0		0
Zg3-2/3a	1.18	Zg	70	Zo	30		0		0		0		0
Zo18-2ab	0.51	Zo	60	I	30	Yk	10		0		0		0
Zo19-1/2ac	1.35	Zo	50	I	30	Qc	10	Rc	10		0		0
Zo20-1/2a	0.19	Zo	60	Yh	30	Rc	10		0		0		0
Zo21-3a	0.03	Zo											
Zo22-2/3a	0.21	Zo	Composition unspecified										
Zo27-3a	0.37	Zo											
Zo28-3a	0.11	Zo	50	Zt	30	Jc	10	Zg	10		0		0

In the FAO classification system, a further differentiation of some soil units may occur on the basis of so-called *phases*.

A soil phase refers to a subdivision of a soil unit based on characteristics which are significant to the use or the management of land but which are not diagnostic for the separation of soil units themselves (FAO, 1974). Phases are used, for example, where indurated layers or hard rock occur at shallow depth.

The following soil phases may occur: stony, lithic, petric, petrocalcic, petrogypsic, petroferric, phreatic, fragipan, duripan, saline, sodic and cerrado. For the definition of these phases is referred to FAO (1974).

Besides soil units, the Digital Soil Map of the World also contains some ‘miscellaneous land units’, which are areas of "non-soil" such as dunes or shifting sands, salt flats, rock debris, desert detritus, glaciers.

Finally, within the database underlying the Digital Soil Map of the World (although not shown on the map itself), the soil units are classified into three textural categories:

- *coarse*: sands, loamy sands and sandy loams, with less than 18 percent clay and more than 65 percent sand;
- *medium*: sandy loams, loams, sandy clay loams, silt loams, silt, silty clay loams and clay loams, with less than 35 percent clay and less than 65 percent sand;
- *fine*: clay, silty clays, sandy clays, clay loams, with more than 35 percent clay.

2.5.3. Derived soil properties

Soil classification units are like robot photos of soils. They are *generalizations* for use at a regional scale but may at local level contain much internal heterogeneity in individual soil properties, such as texture, structure, organic matter, depth, and chemical properties.
The values of these soil properties are obtained from samples obtained from *soil profiles*, of which there are few worldwide. For example, the most comprehensive global soil profile data, the WISE database (Batjes et al., 2002), contains slightly more than 4,000 soil profiles worldwide. Nevertheless, by linking the values of individual soil properties from these reference soil profiles (and from other profiles in area-specific soil studies) to the FAO soil classification units, soil scientists were able to assess the likely ranges of soil property values for the different FAO soil units.

The following soil properties were derived from the FAO soil classification units:

- Acid soils
- Soils with high risk of aluminium toxicity
- Calcareous soils
- Saline soils
- Soils with high sodium content
- Soils with low organic matter content
- Soils with moderate organic matter content
- Soils with high organic matter content
- Coarse-textured soils
- Medium-textured soils
- Fine-textured soils
- Soils with excessive wetness
- Shallow soils
- Stony soils
- Soils with high risk of phosphorus fixation
- Soils with vertic properties
- Indurated soils
    - With Petric phase
    - With Petrocalcic phase

- With Petrogypsic phase
- With Petroferric phase
- With Fragipan phase
- With Duripan phase

The methods for extracting these properties are explained in the following sections.

2.5.3.1. Acid soils

Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) as having:

- 10-60% Al-saturation of the effective cation exchange capacity (CEC) within 50 cm of soil surface, or
- pH in 1:1 H_20 between 5.0 and 6.0

Within the FAO soil classification system these soils are identified as follows:

- All Podsols and Rankers
- All Luvisols and Cambisols, except the 'Calcic', 'Eutric' and 'Vertic' subgroups
- The 'Dystric' subgroups of the Regosol, Nitosol, Histosol and Fluvisol soil groups
- The 'Humic' subgroups of the Gleysol, Andosol, Ferralsol, Nitosol, Acrisol and Planosol soil groups

2.5.3.2. Soils with high risk of aluminium toxicity

Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) as having:

- >60% Al-saturation of the effective CEC within 50 cm of the soil surface, or
- >67% acidity saturation of CEC by Σ cations at pH 7 within 50 cm of the soil surface, or
- >86% acidity saturation of CEC by Σ cations at pH 8.2 within 50 cm of the soil surface, or
- pH 5.0 or less in 1:1 H_20 within 50 cm, except in organic soils where pH must be less than 4.7

Within the FAO soil classification system these soils are identified as follows:

- All soils of the Ferralsol or Acrisol groups, except the 'Humic' subgroups
- The 'Dystric' subgroups of the Cambisol, Gleysol and Planosol soil groups

2.5.3.3. Soils with basic reaction (Calcareous soils)

Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) having free CaCO3 within 50 cm of the soil surface (effervescence with HCl) or pH> 7.3.

Within the FAO soil classification system these soils are identified as:

- All soils of the Chernozem and Rendzina soil groups
- All soils of the Xerosol and Yermosol soil groups, except the 'Luvic' subgroups
- All soils with *petrocalcic* or *petrogypsic* phase
- The non-sandy Calcic Cambisols.

2.5.3.4. Saline soils

Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) as having '> 4 dS/m of electrical conductivity of saturated extract at 25°C within 1 m of the soil surface'

Within the FAO soil classification system these soils are identified as follows:

- All soils in the Solonchak soil group
- Other soils with *saline phase*

The miscellaneous land unit *Salt Flats* is retained as a separate layer.

2.5.3.5. Soils with high sodium content

Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) as having '> 15% sodium saturation of the cation exchange capacity within 50 cm of the soil surface'. These soils, with high sodium content, are not saline.
Within the FAO soil classification system these soils are identified as follows:

- All soils in the Solonetz soil group
- The Solodic Planosol soil unit
- Other soils with *sodic phase*

2.5.3.6. Soils with low, moderate and high organic matter content

- Soils with low organic matter content: organic carbon percentage of the topsoil is < 0.6%.
- Soils with moderate organic matter content: organic carbon percentage of the topsoil is 0.6-2%.
- Soils with high organic matter content: organic carbon percentage of the topsoil is > 2%.

The mapping of this property is based on the statistical relationships between the FAO soil units and soil organic carbon. FAO has collected soil profile information from field projects, the soil profile information contained in the volumes that accompanied the Soil Map of the World (FAO-Unesco, 1971-81), that published in Soil Taxonomy (Soil Survey Staff, 1972) and that released by ISRIC. A total of 1700 soil profiles were analyzed and grouped by FAO Soil Unit and Topsoil Texture group. Statistical (weighted) averages were calculated for the topsoil (0-30 cm) and for the subsoil (30-100 cm) for, amongst other chemical parameters, the organic carbon percentage. As there were no representative soil profiles for all combinations of Soil Unit-Topsoil texture, this database was complemented through expert opinion from inside and outside FAO.

2.5.3.7. Soils with coarse, medium- and fine-textured soils

The textural classes refer to the relative proportions of the soil size components sand, silt and clay. A *coarse-textured* soil contains less than 18% clay and more than 65% sand. A *medium-textured* soil contains 18-35% clay and less than 65% sand. A *fine-textured* soil contains >35% clay.

The areas with soils of different textures are obtained from the Soil Mapping Unit Composition File, which is part of the database for the Digital Soil Map of the World. The structure of this file is as follows:

(1) Soil Mapping Unit Number;
(2) Soil Mapping Unit Symbol (similar to the one on the paper map);
(3) Phase Number (between 1 and 12) followed by Permafrost information (if applicable);
(4) Dominant Soil Unit (FAO-Unesco 1974 Legend);
(5) Percentage of dominant soil unit (soil unit 1)
(6) Composition of soil unit 1 (% that belongs to texture-slope class):
1a 1b 1c 2a 2b 2c 3a 3b 3c 4d
(7) First associated soil unit (legend symbol soil unit 2)

(8) Percentage of first associated soil unit
(9) Composition of soil unit 2 (% that belongs to texture-slope class):

1a	1b	1c	2a	2b	2c	3a	3b	3c	4d

....
(88) Soil unit 8 (Legend symbol)
(89) Percentage of soil unit 8
(90) % of soil unit 8 that belongs to texture-slope class:

1a	1b	1c	2a	2b	2c	3a	3b	3c	4d

In total there are 99 fields.
1, 2 and 3 stand for respectively coarse, medium and fine textures and a, b, c stand for respectively flat (0-8% slope), undulating (8-30% slope) and hilly terrain (> 30% slope).

2.5.3.8. Soils with excessive wetness
Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) either with mottles <2 chroma within 60 cm of the soil surface and below all A horizons, or saturated with water for >60 days in most years.
Within the FAO soil classification system these soils are identified as:

- All soils of the Gleysol, Planosol and Histosol soil groups
- All soils with 'Gleyic' subgroup
- Thionic Fluvisols

2.5.3.9. Shallow soils
Within the FAO soil classification system these soils include all Lithosols (I), Rendzinas (E), Rankers (U), as well as soils with *Lithic* phase and Rock Outcrops (ROCK). In addition, half of the area with soils that have a *Petrocalcic, Petrogypsic, Petroferric* or *Duripan* phase, are included in this category.

2.5.3.10. Stony soils
Within the FAO soil classification system these soils are identified as those with *stony phase*.

2.5.3.11. Soils with high risk of phosphorus fixation by iron
Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) as having more than 35% clay and (i) a ratio (% free Fe2 O3/% clay) > 0.15 or (ii) hues of 7.5 YR or redder and granular structure.
This feature applies to the plow-layer or surface 20 cm of soil surface, whichever is shallower.
Within the FAO soil classification system these soils are identified as clayey Ferralsols and Acrisols.

2.5.3.12. Soils with vertic properties
Using the Fertility Capability Classification (FCC), these soils are defined as (Sanchez et al., 1982) very sticky plastic clays (> 35% clay) with either >50% consist of 2:1 expanding clays, or with severe topsoil shrinking and swelling.
Within the FAO soil classification system these soils are identified as all Vertisols, as well as the 'Vertic' subgroups of Luvisols and Cambisols.

2.5.3.13. Indurated soils
Within the FAO soil classification system these soils are identified as those with *Petric, Petrocalcic, Petrogypsic, Petroferric, Fragipan*, or *Duripan* phase

A *Petric* phase marks soils that contain 40% or more of oxidic concretions, hardened plinthite or ironstone over a thickness of at least 25 cm within 1 m of the surface

A *Petroferric* phase is similar but the layer of concretions is continuously cemented.

A *Fragipan* phase distinguishes soils that have a loamy subsurface horizon (‘Fragipan’) within 1 m of the surface, with a high bulk density relative to the horizons above it, that is hard or very hard and cemented when dry and weakly brittle when moist, low in organic matter, and slowly permeable.

A *Duripan* phase marks soils that have a subsurface horizon (‘Duripan’) within 1 m of the surface cemented by silica. According to the FAO Soil Map of the World these soils do not occur in the CWANA and Eurasia region.

A *Petrocalcic* phase marks soils that have within 100 cm of the surface a horizon that is continuously cemented by calcium carbonates.

A *Petrogypsic* phase marks soils that have within 100 cm of the surface a horizon that is cemented with gypsum, usually containing >60% gypsum.

2.5.4. Mapping of soil properties

In the Digital Soil Map of the World soil properties are mapped by linking the FAO soil association map to the *soil mapping unit composition file*.

Using the decision rules explained earlier for the individual derived soil properties, the FAO Digital Soil Map of the World allows to obtain the percentages that each derived soil property occupies within a grid cell of maximum resolution of 5 arc minutes (or about 10 km).

This resolution was considered too low. For this reason the mapping program of the Digital Soil Map of the World (IMAGES.BAS) was modified to create new ASCII raster export files with 30 arc second resolution, using the same transformation rules to derive the percentages of the individual soil properties but at a 10 times higher resolution.
It needs to be noted that this procedure is simply a GIS manipulation to obtain a higher-resolution output, but that this does not in any way increase its accuracy, which remains bound to the 1:5,000,000 scale of the original FAO Soil Map of the World.

Another important point is that, in contrast with the climatic data, the accession sites can not be assigned a definite value, only a likelihood of occurrence, in accordance with the estimates of the Soil Map of the World. In most cases these are rough estimates, based on surveys of different reliability, which refer to areas and do not necessarily apply to the particular accession sites.

3. DATASET TABLES

3.1. Data files

Table 4. List of files

Filename	Description
ACZ.xls	Agroclimatic zones
Arid.xls	Aridity indices
GPend.xls	Growing period end dates
GPon.xls	Growing period onset dates
LGP.xls	Length of growing period data
PET.xls	Potential evapotranspiration data
Prec.xls	Precipitation data
Q1.xls	Autumn precipitation share of annual precipitation
Q2.cls	Winter precipitation share of annual precipitation
Q3.xls	Spring precipitation share of annual precipitation
Q4.xls	Summer precipitation share of annual precipitation
Soils.xls	Soil property distribution Mean temperature data
Temp.xls	Mean temperature data
Tmax.xls	Maximum temperature data
Tmin.xls	Minimum temperature data

3.2. General record structure

All dataset tables are in Excel format and contain 4651 records. The records have the following structure:

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: Value 1: Feature X
- (Column G: Value 2, Column H: Value 3…)

In all tables a -9999 value means '*missing value'.* A missing value can be due to the fact that accession sites are located in areas for which no data are available yet, such as:

- the American continent (153);
- Australia (1);
- Java (1);
- Mali (2);
- South Africa (1)

In other cases the accession sites are located in the in the sea due to slightly misplaced coordinates (60) or the coordinates are not defined (7).
In the tables related to growing period features (GPend.xls, GPon.xls and LGP.xls) the vast majority of the records has a -9999 value for some attributes, meaning that the attribute does not occur for the particular record (see further).

3.3. Agroclimatic zones

3.3.1. Record structure ACZ.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: Pixel value
- Column G: Code for agroclimatic zone
- Column H: Agroclimatic zone symbol
- Column I: Moisture regime
- Column J: Aridity index class
- Column K: Winter temperature regime
- Column L: Temperature range coldest month of the year
- Column M: Summer temperature regime
- Column N: Temperature range warmest month of the year

3.3.2. Record structure Arid.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: Aridity index January
- Column G: Aridity index February
- Column H: Aridity index March
- Column I: Aridity index April
- Column J: Aridity index May
- Column K: Aridity index June
- Column L: Aridity index July
- Column M: Aridity index August
- Column N: Aridity index September
- Column O: Aridity index October
- Column P: Aridity index November
- Column Q: Aridity index December
- Column R: Annual Aridity index

It is to be noted that a monthly aridity index is defined in a similar way as the annual aridity index, as the ratio of *monthly* precipitation over the *monthly* potential evapotranspiration.

3.4. Length, onset and end dates of growing period

3.4.1. Record structure GPend.xls

- Column A: ID: Accession code 1

- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F (Field GPend1): end of the first moisture-limited growing period
- Column G (Field GPend2): end of the second moisture-limited growing period
- Column H (Field GPend3): end of the third moisture-limited growing period
- Column I (Field GPend4): end of the first temperature-limited growing period
- Column J (Field GPend6): end of the first moisture- and temperature-limited growing period
- Column K (Field GPend7): end of the second moisture- and temperature-limited growing period
- Column L (Field GPend8): end of the third moisture- and temperature-limited growing period

The values are between 1 and 365 and indicate day numbers in a standard year e.g. 45 =14 February (31 days in Jan + 14 days in February); 239= 16 September (31 days in Jan + 28 (Feb) + 31 (Mar) + 30 (Apr) + 31 (May) + 30 (Jun) + 31 (Jul) + 31 (Aug) + 16 in Sep).
If the value exceeds 365 the day is obtained by subtracting 365, as in the right-hand part of the spreadsheet.
If a record has a value for a GPend attribute of 365 and of 1 for a GPon attribute, the growing period is 'continuous' throughout the year.
The value -9999 in a field may mean either a missing value or that the particular kind of growing period does not occur, and therefore can not have an end. To know which is which, an extra field 'Missing Value' has been added. If this field has the value -9998, it means that the value -9999 in the other fields is due to a true missing value. If the field is blank, the -9999 values in the other fields means that the particular attribute does not exist.

3.4.2. Record structure GPon.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F (Field GPon1): onset of the first moisture-limited growing period
- Column G (Field GPon2): onset of the second moisture-limited growing period
- Column H (Field GPon3): onset of the third moisture-limited growing period
- Column I (Field GPon4): onset of the first temperature-limited growing period
- Column J (Field GPon6): onset of the first moisture- and temperature-limited growing period
- Column K (Field GPon7): onset of the second moisture- and temperature-limited growing period
- Column L (Field GPon8): onset of the third moisture- and temperature-limited growing period

The values are between 1 and 365 and indicate day numbers in a standard year e.g. 45 =14 February (31 days in Jan + 14 days in February); 239= 16 September (31 days in Jan + 28 (Feb) + 31 (Mar) + 30 (Apr) + 31 (May) + 30 (Jun) + 31 (Jul) + 31 (Aug) + 16 in Sep).

If the value exceeds 365 the day is obtained by subtracting 365, as in the right-hand part of the spreadsheet.
If a record has a value for a GPon attribute of 1 and of 365 for a GPend attribute, the growing period is 'continuous' throughout the year.
The value -9999 in a field may mean either a missing value or that the particular kind of growing period does not occur, and therefore can not have an end. To know which is which, an extra field 'Missing Value' has been added. If this field has the value -9998, it means that the value -9999 in the other fields is due to a true missing value. If the field is blank, the -9999 values in the other fields means that the particular attribute does not exist.

3.4.3. Record structure LGP.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F (Field LGP1): duration first moisture-limited growing period
- Column G (Field LGP2): duration second moisture-limited growing period
- Column H (Field LGP3): duration third moisture-limited growing period
- Column I (Field LGP4): duration first temperature-limited growing period
- Column J (Field LGP6): duration first moisture- and temperature-limited growing period
- Column K (Field LGP7): duration second moisture- and temperature-limited growing period
- Column L (Field LGP8): duration third moisture- and temperature-limited growing period

The field values are between 0 and 365 days.

3.5. Other climatic variables

3.5.1. Record structure PET.xls
- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: PET January
- Column G: PET February
- Column H: PET March
- Column I: PET April
- Column J: PET May
- Column K: PET June
- Column L: PET July
- Column M: PET August
- Column N: PET September
- Column O: PET October
- Column P: PET November
- Column Q: PET December

- Column R: Annual PET

The values are expressed in mm.

3.5.2. Record structure Prec.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: Precipitation January
- Column G: precipitation February
- Column H: precipitation March
- Column I: precipitation April
- Column J: precipitation May
- Column K: precipitation June
- Column L: precipitation July
- Column M: precipitation August
- Column N: precipitation September
- Column O: precipitation October
- Column P: precipitation November
- Column Q: precipitation December
- Column R: Annual precipitation

The values are expressed in mm.

3.5.3. Record structure Q1-winter.xls, Q2-spring.xls, Q3-summer.xls, Q4-autumn.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: proportion (%) of the annual precipitation that falls in winter (Q1-winter.xls), in spring (Q2-spring.xls), in summer (Q3-summer.xls), and in autumn (Q4-autumn.xls)

3.5.4. Record structure Temp.xls, Tmax.xls, Tmin.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: Monthly temperature January
- Column G: Monthly temperature February
- Column H: Monthly temperature March
- Column I: Monthly temperature April
- Column J: Monthly temperature May
- Column K: Monthly temperature June
- Column L: Monthly temperature July
- Column M: Monthly temperature August
- Column N: Monthly temperature September

- Column O: Monthly temperature October
- Column P: Monthly temperature November
- Column Q: Monthly temperature December
- Column R: Annual average temperature

In Temp.xls ‘monthly temperature’ means: average mean temperature for the month
In Tmax.xls ‘monthly temperature’ means: average maximum temperature for the month
In Tmin.xls ‘monthly temperature’ means: average minimum temperature for the month

3.6. Soils

3.6.1. Record structure Soils.xls

- Column A: ID: Accession code 1
- Column B: ACP: Accession code 2
- Column C: ACNO: Accession code 3
- Column D: DECLAT: Latitude (decimal degrees)
- Column E: DECLONG: Longitude (decimal degrees)
- Column F: proportion of a pixel (%) containing acid soils
- Column G: proportion of a pixel (%) containing soils with high risk of aluminium toxicity
- Column H: proportion of a pixel (%) containing calcareous soils
- Column I: proportion of a pixel (%) containing coarse-textured soils
- Column J: proportion of a pixel (%) containing soils with duripan
- Column K: proportion of a pixel (%) containing fine-textured soils
- Column L: proportion of a pixel (%) containing soils with fragipan
- Column M: proportion of a pixel (%) containing soils with low organic matter content
- Column N: proportion of a pixel (%) containing medium-textured soils
- Column O: proportion of a pixel (%) containing soils with moderate organic matter content
- Column P: proportion of a pixel (%) containing soils with high organic matter content
- Column Q: proportion of a pixel (%) containing soils with petric phase
- Column R: proportion of a pixel (%) containing soils with petrocalcic phase
- Column S: proportion of a pixel (%) containing soils with petroferric phase
- Column T: proportion of a pixel (%) containing soils with petrogypsic phase
- Column U: proportion of a pixel (%) containing soils with high risk of phosphorus fixation
- Column V: proportion of a pixel (%) containing saline soils
- Column W: proportion of a pixel (%) containing shallow soils
- Column X: proportion of a pixel (%) containing soils with high sodium content
- Column Y: proportion of a pixel (%) containing stony soils

The explanation for these terms is provided in the section ‘Derived soil properties’ of the Methods chapter.

References

Allen R.G., Pereira L.S., Raes D., Smith M. 1998. Crop evapotranspiration. Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56, 300 pp., FAO, Rome

Batjes, N.H. 2002. A homogenized soil profile dataset for global and regional environmental research (WISE version 1.1). Report 2002/01, 38 pp. ISRIC, Wageningen, the Netherlands.

Choisnel E., de Villele O., Lacroze F. 1992. Une approche uniformisée du calcul de l'évapotranspiration potentielle pour l'ensemble des pays de la Communauté Européenne Centre Commun de Recherche, Commission des Communautés Européennes, EUR 14223, 178 pp.

Debaveye, J. 1985. Soil survey technical documents. Vol.2: Handbook for data interpretation. Soil Survey and Assessment Project. Department of Development Cooperation, Min. Foreign Trade and Foreign Affairs, Belgium

De Pauw, E. 2002. An agroecological exploration of the Arabian Peninsula. ICARDA, Aleppo, Syria, 77 pp. ISBN 92-9127-119-5.

De Pauw, E., F. Pertziger and L. Lebed. 2004a. Agroclimatic mapping as a tool for crop diversification in Central Asia and the Caucasus. In J. Ryan, P. Vlek, and R. Paroda (Eds.). Agriculture in Central Asia: Research for Development. ICARDA, Aleppo, pp. 21-43.

De Pauw, E, , A. Ghaffari , V. Ghasemi. 2004b. Agroclimatic Zones Map of Iran. Explanatory notes. ICARDA Technical Report.

FAO. 1974. FAO-UNESCO Soil Map of the World. Vol.I: Legend.
UNESCO, Paris

FAO. 1978. Report of the Agroecological Zones Project. Vol.1 Africa. World Soil Resources Report no.48, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 1988. FAO-UNESCO Soil Map of the World: Revised Legend.
World Soil Resources Report 60. Food and Agriculture Organization, Rome

FAO-UNESCO. 1995. The Digital Soil Map of the World and Derived Soil Properties. Land and Water Digital Media Series 1. FAO, Rome. CD-ROM.

FAO. 2001. FAOCLIM, a CD-ROM with world-wide agroclimatic data, version 2. Environment and Natural Resources Service (SDRN) Working Paper No.5, Food and Agriculure Organization of the United Nations, Rome, Italy

Hutchinson, M.F. 1995. Interpolating mean rainfall using thin plate smoothing splines. Int. J. Geogr. Info. Systems 9: 385-403.

Hutchinson, M.F. 2000. ANUSPLIN version 4.1. User Guide. Center for Resource and Environmental Studies, Australian National University, Canberra.
On-line document: http://cres.anu.edu.au

Köppen W. and Geiger H. 1928. Handbuch der Klimatkunde. Berlin, Germany

Sanchez, P.A., Couto, W. and Buol, S.W. 1982. The Fertility Capability Classification: interpretation, applicability and modification. Geoderma,27 (1982) pp 283 - 309.

UNESCO, 1979. Map of the world distribution of arid regions. Map at scale 1:25,000,000 with explanatory note. United Nations Educational, Scientific and Cultural Organization, Paris, 54 pp. ISBN 92-3-101484-6

ANNEX 1. CLIMATIC MAPS

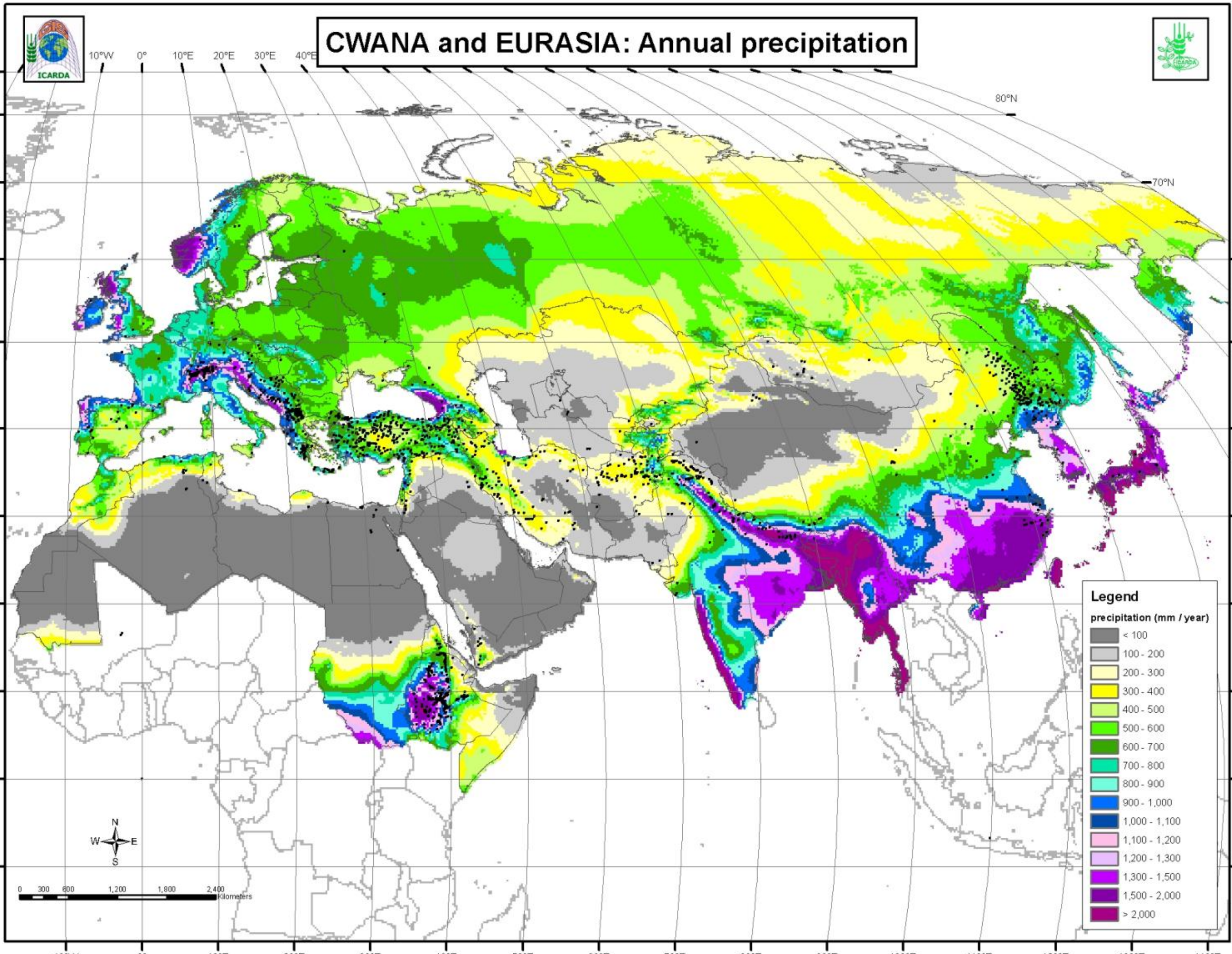


Figure A1.1. Annual precipitation

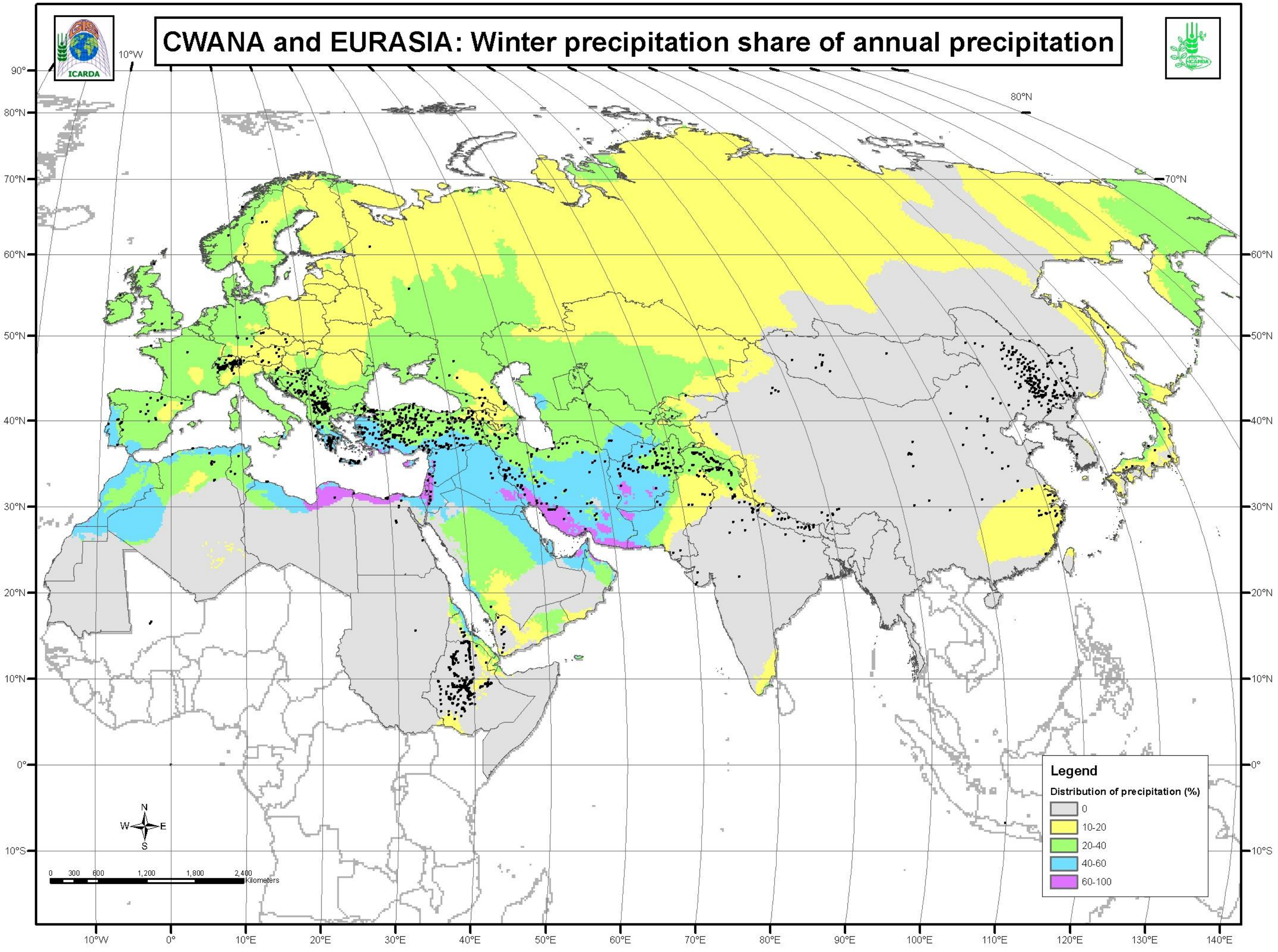


Figure A1.2. Proportion of annual precipitation in winter (December-January-February)

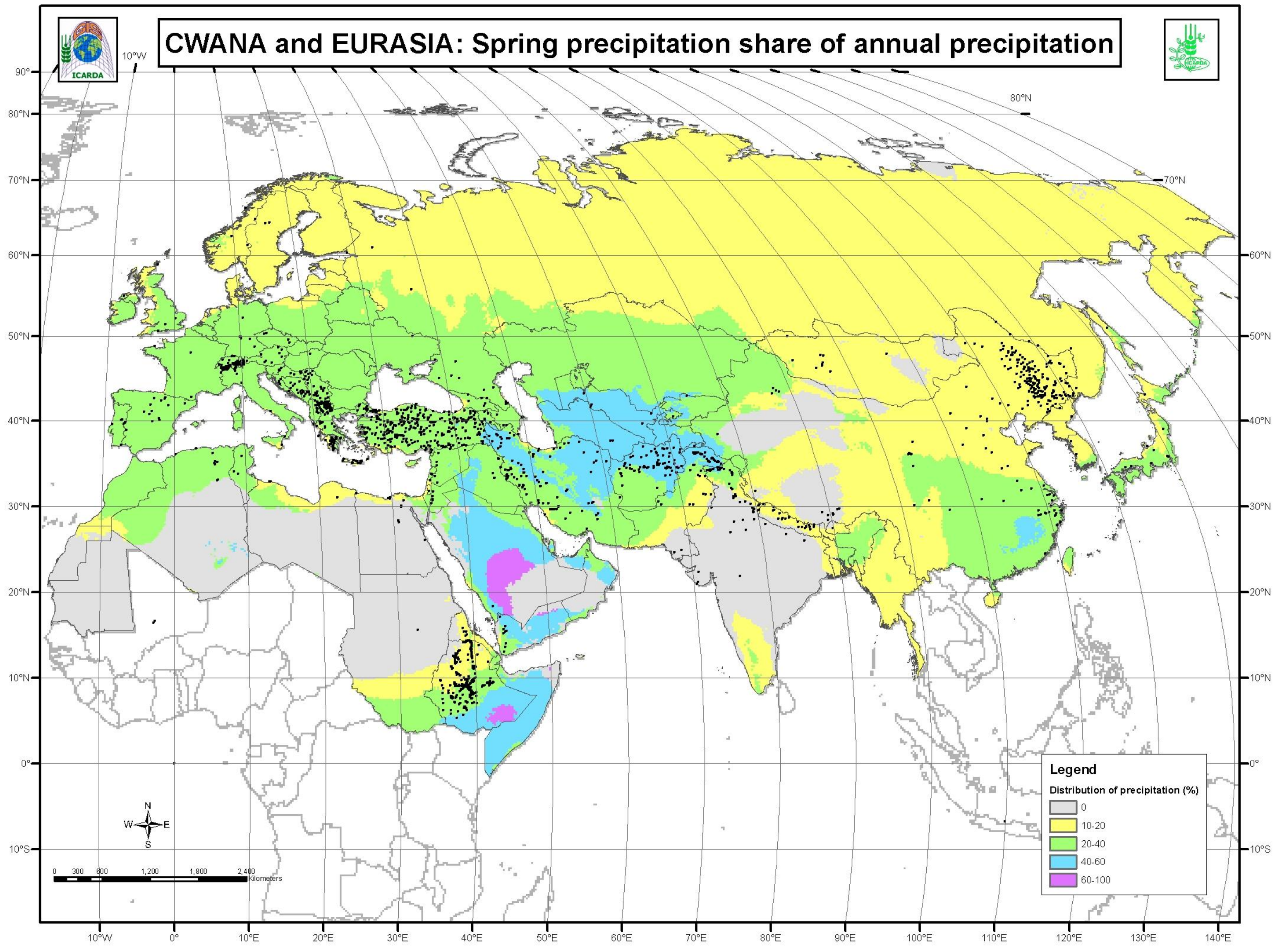


Figure A1.3. Proportion of annual precipitation in spring (March-April-May)

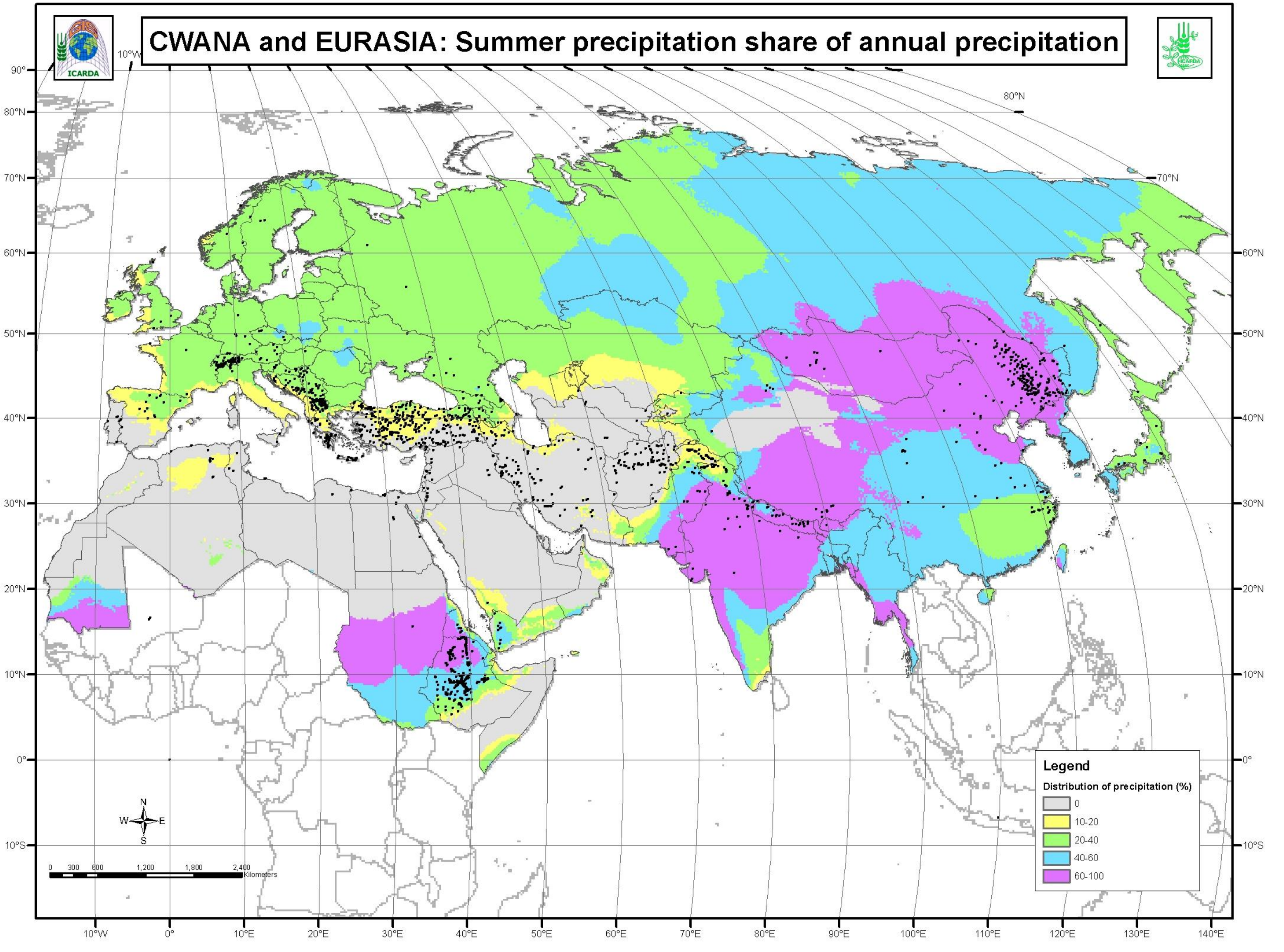


Figure A1.4. Proportion of annual precipitation in summer (June-July-August)

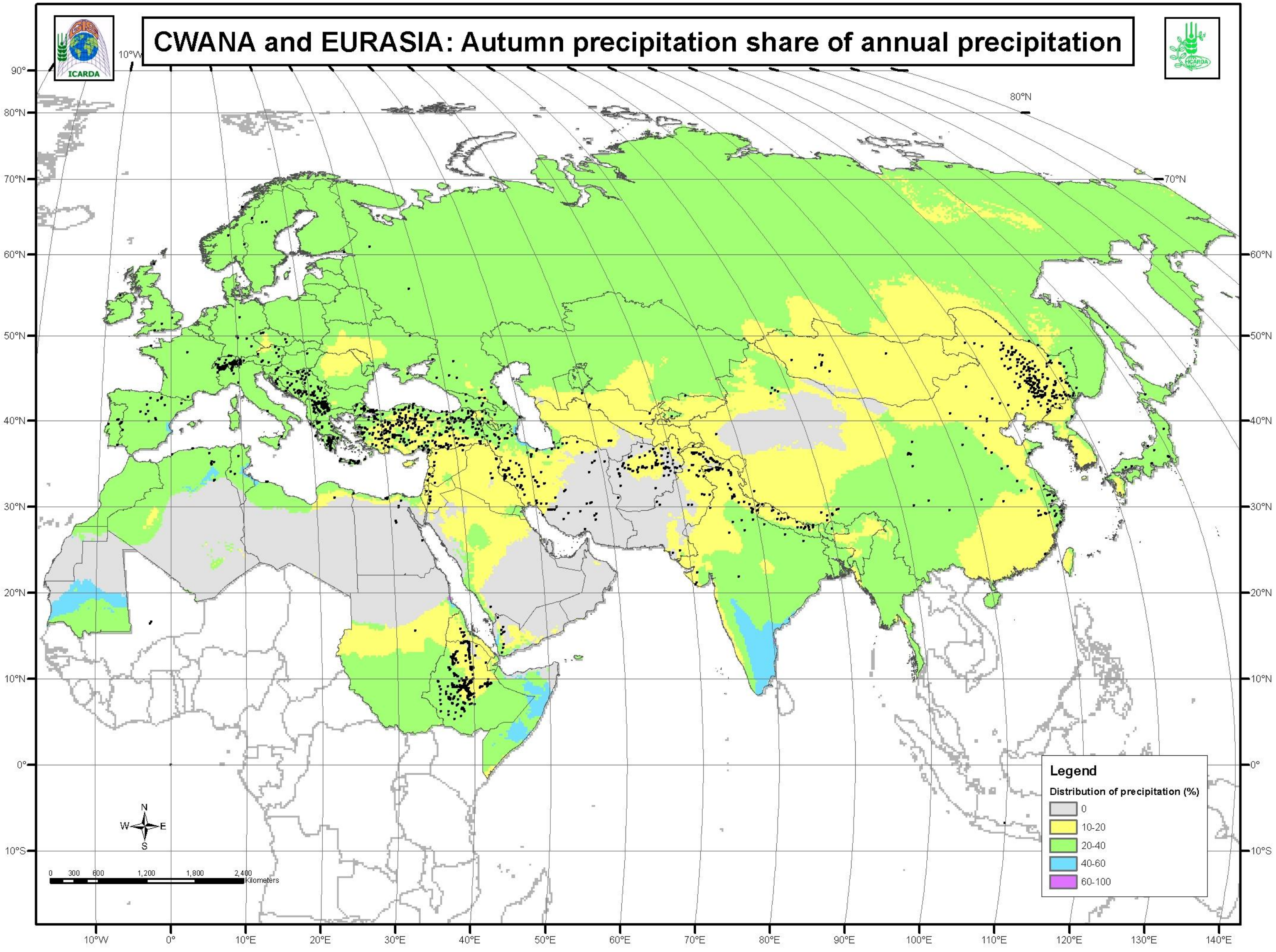


Figure A1.5. Proportion of annual precipitation in autumn (September-October-November)

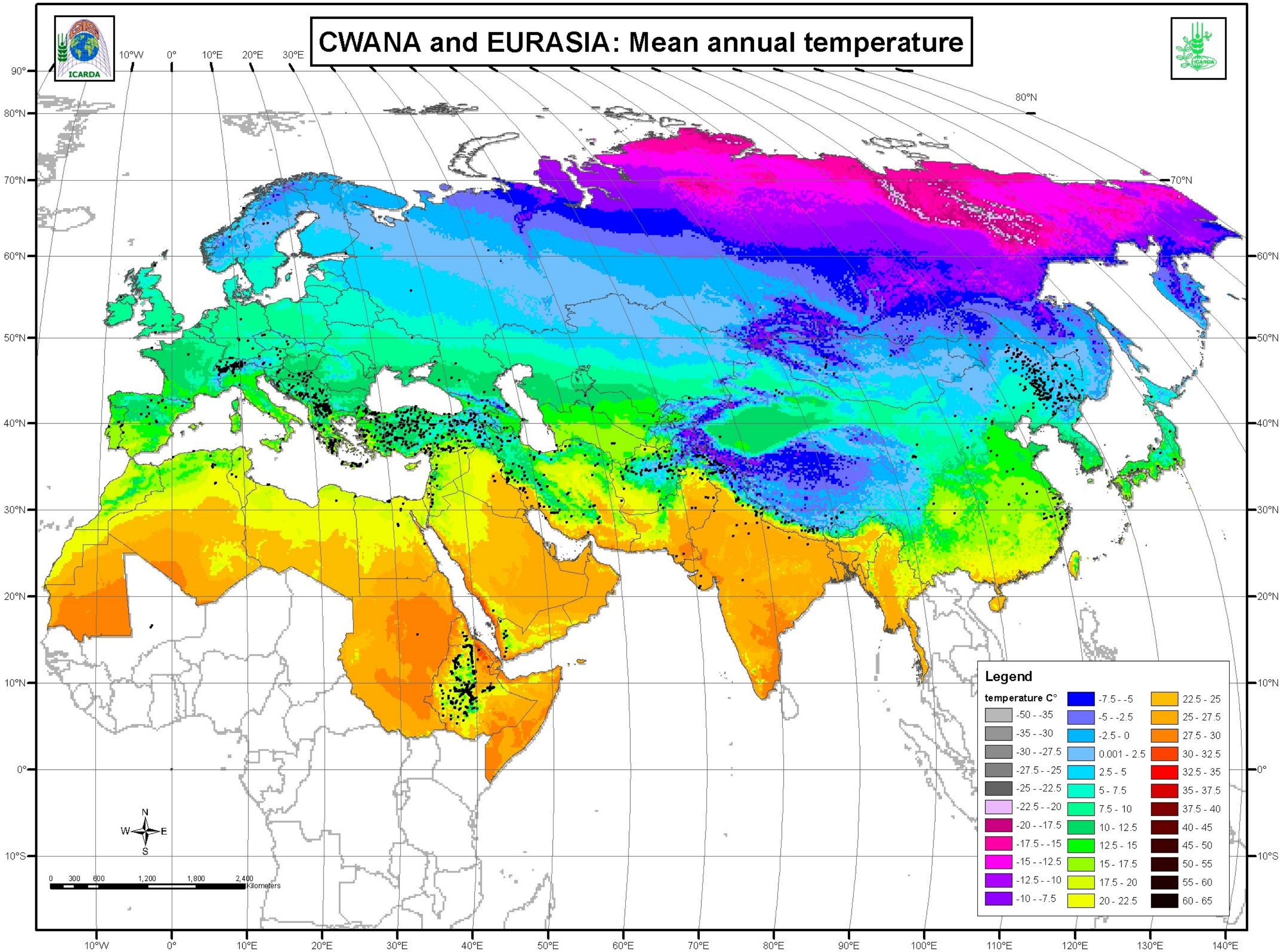


Figure A1.6. Mean annual temperature

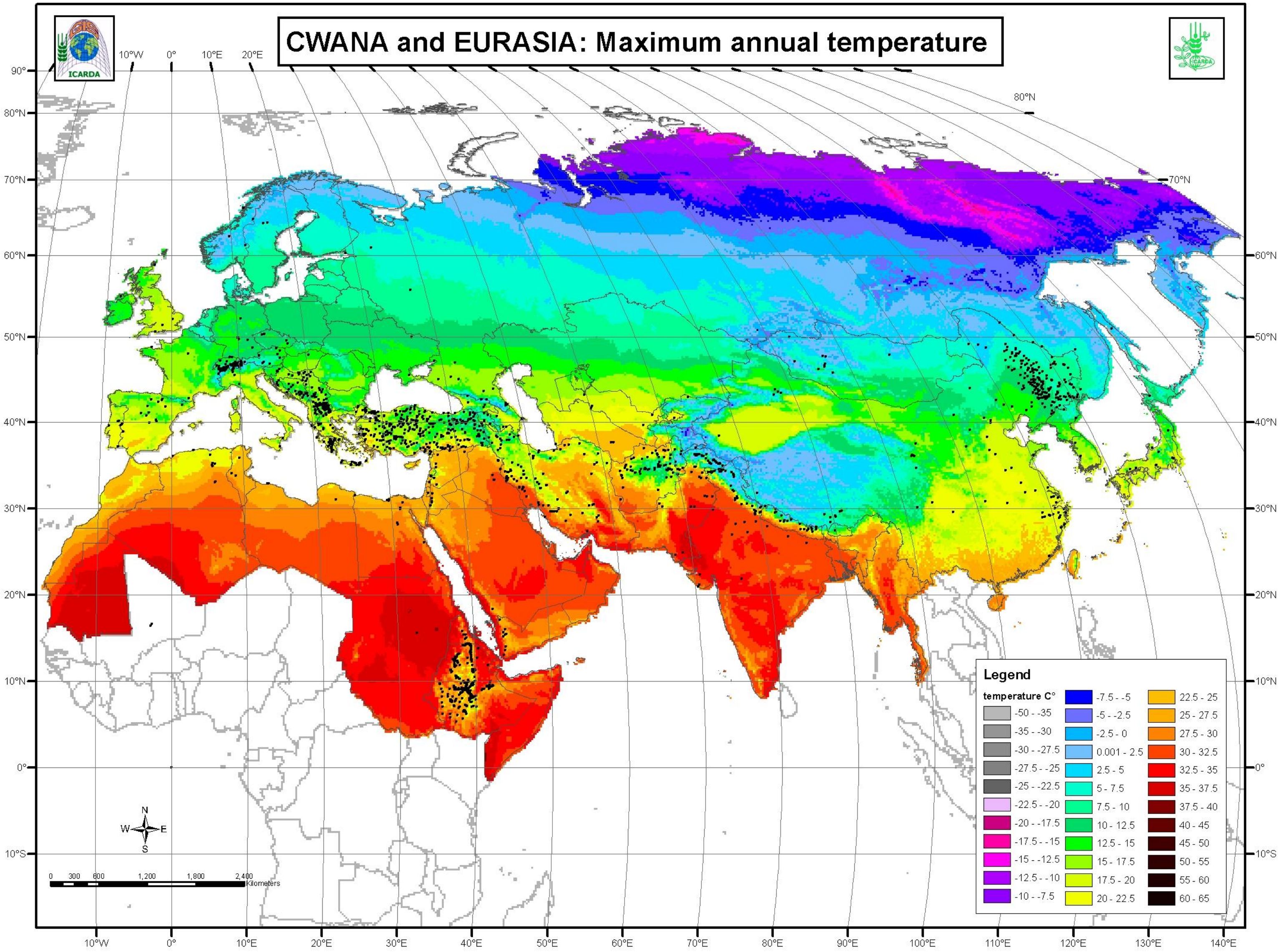


Figure A1.7. Maximum annual temperature

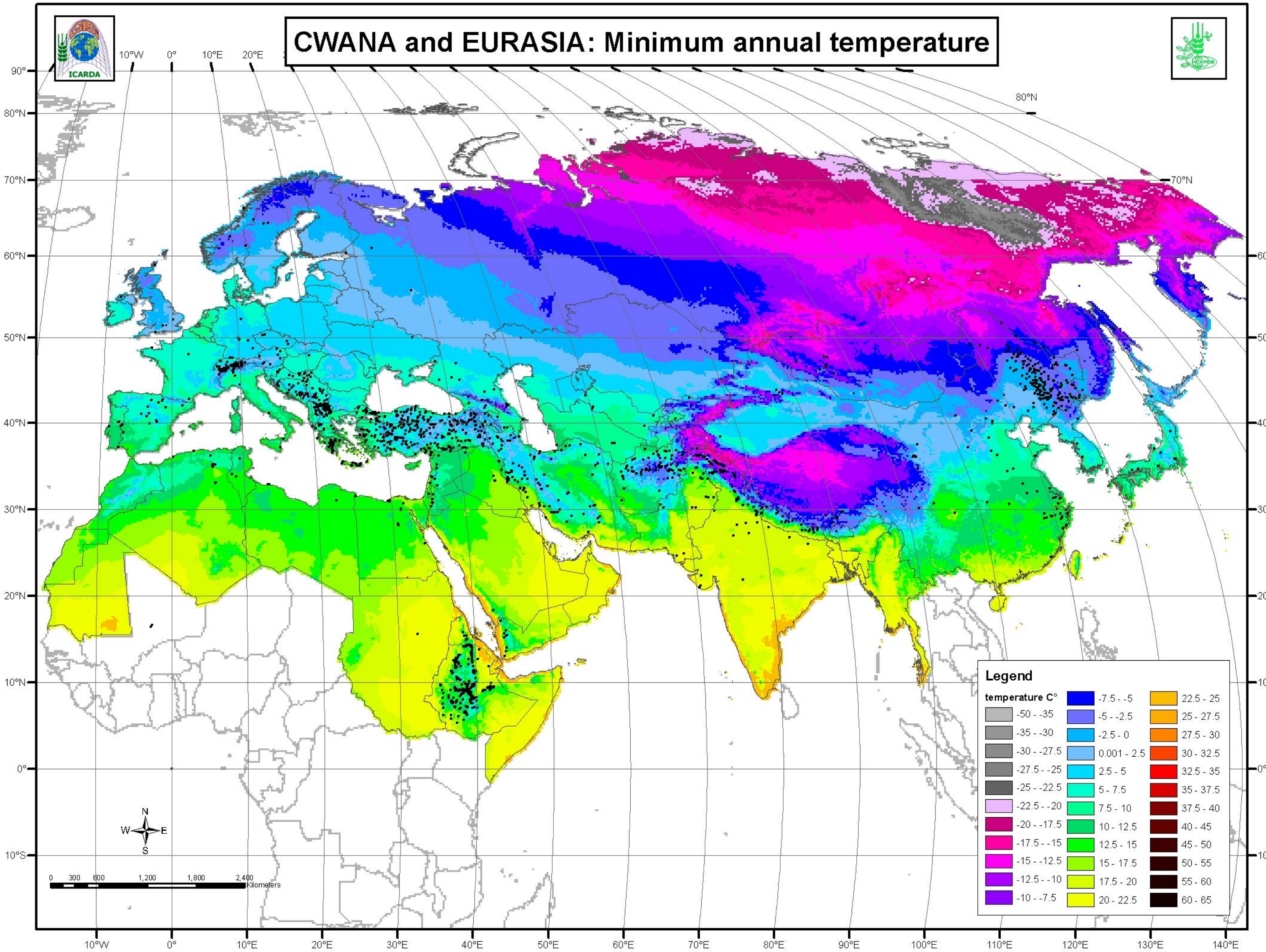


Figure A1.8. Minimum annual temperature

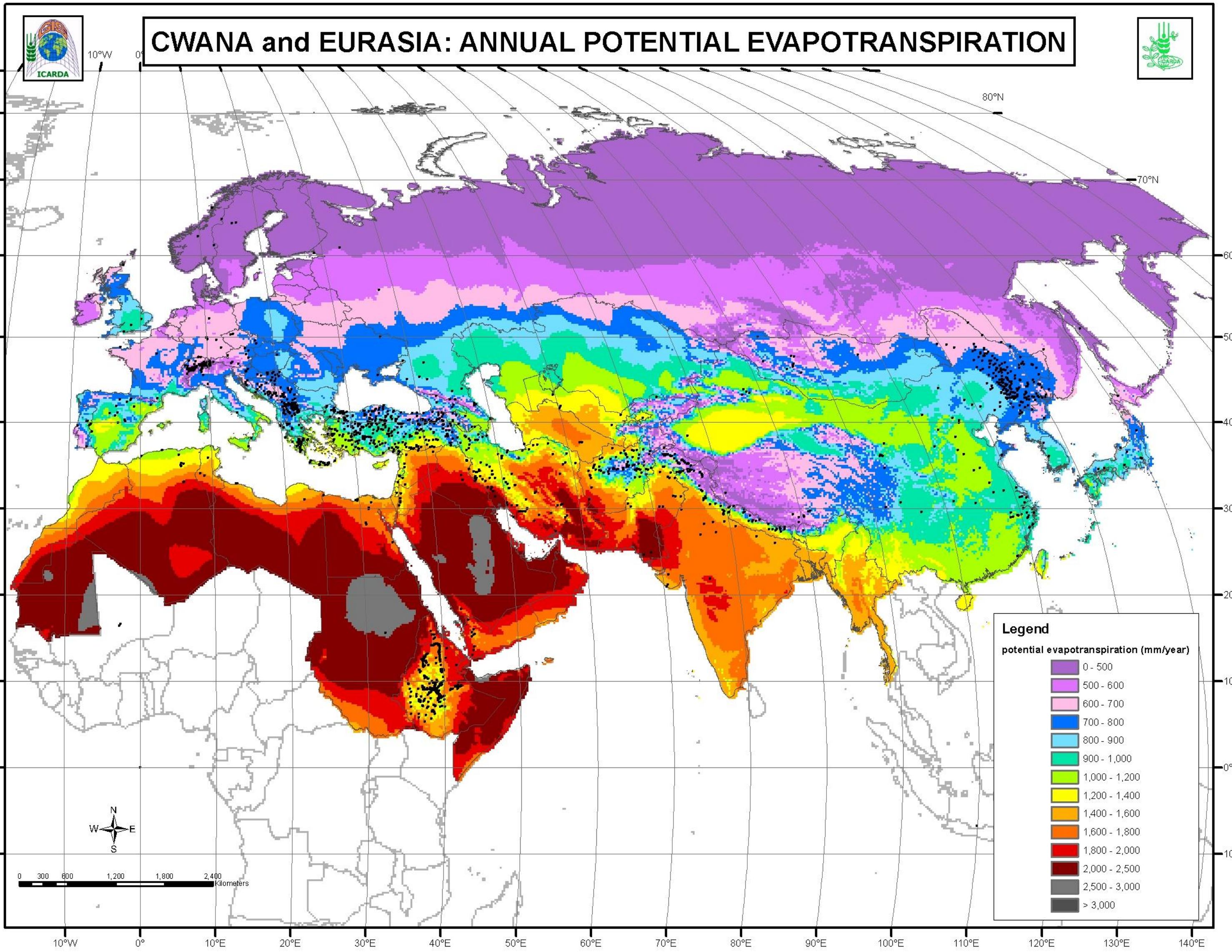


Figure A1.9. Mean annual potential evapotranspiration

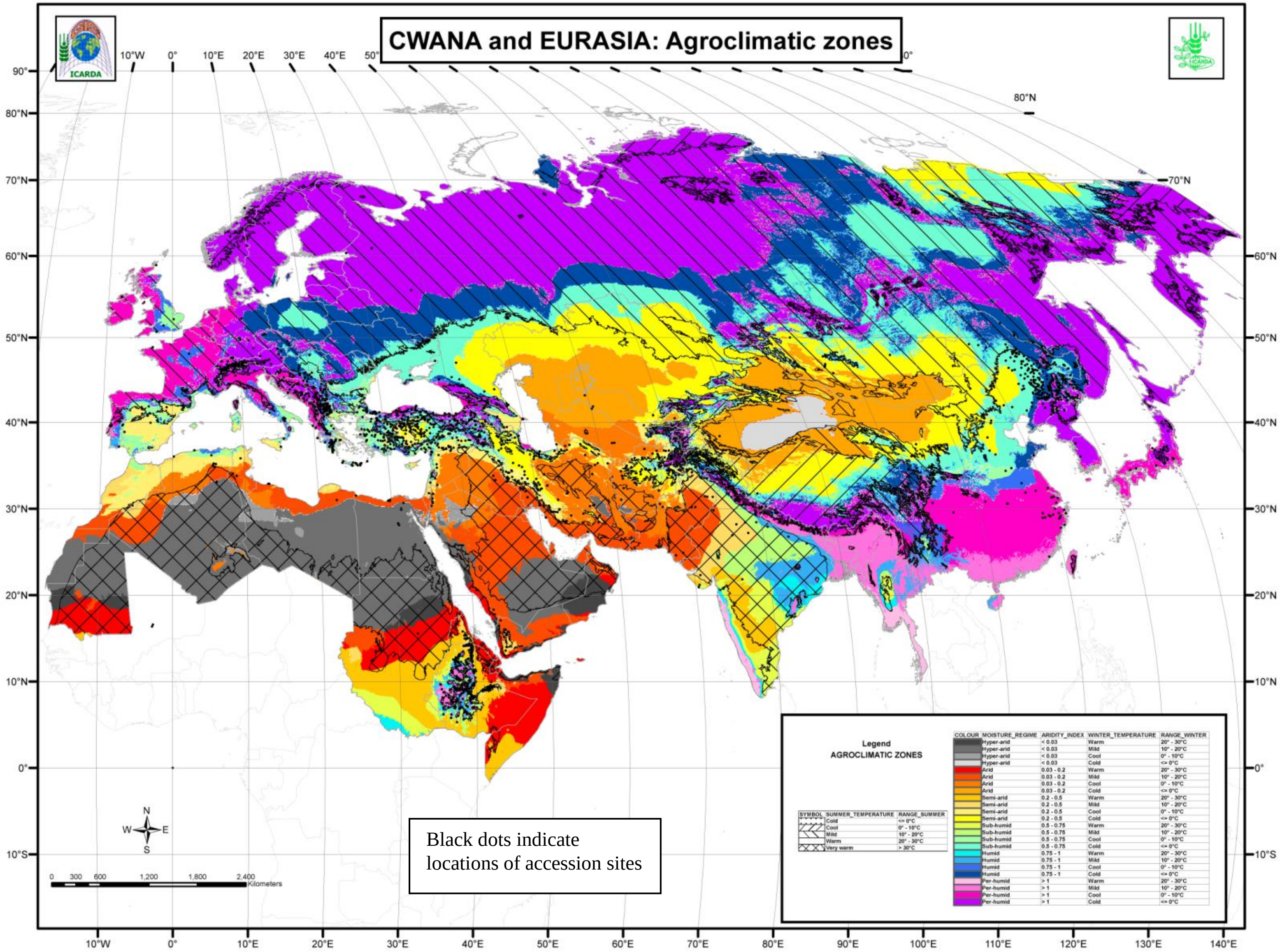


Figure A1.10. Agroclimatic zones

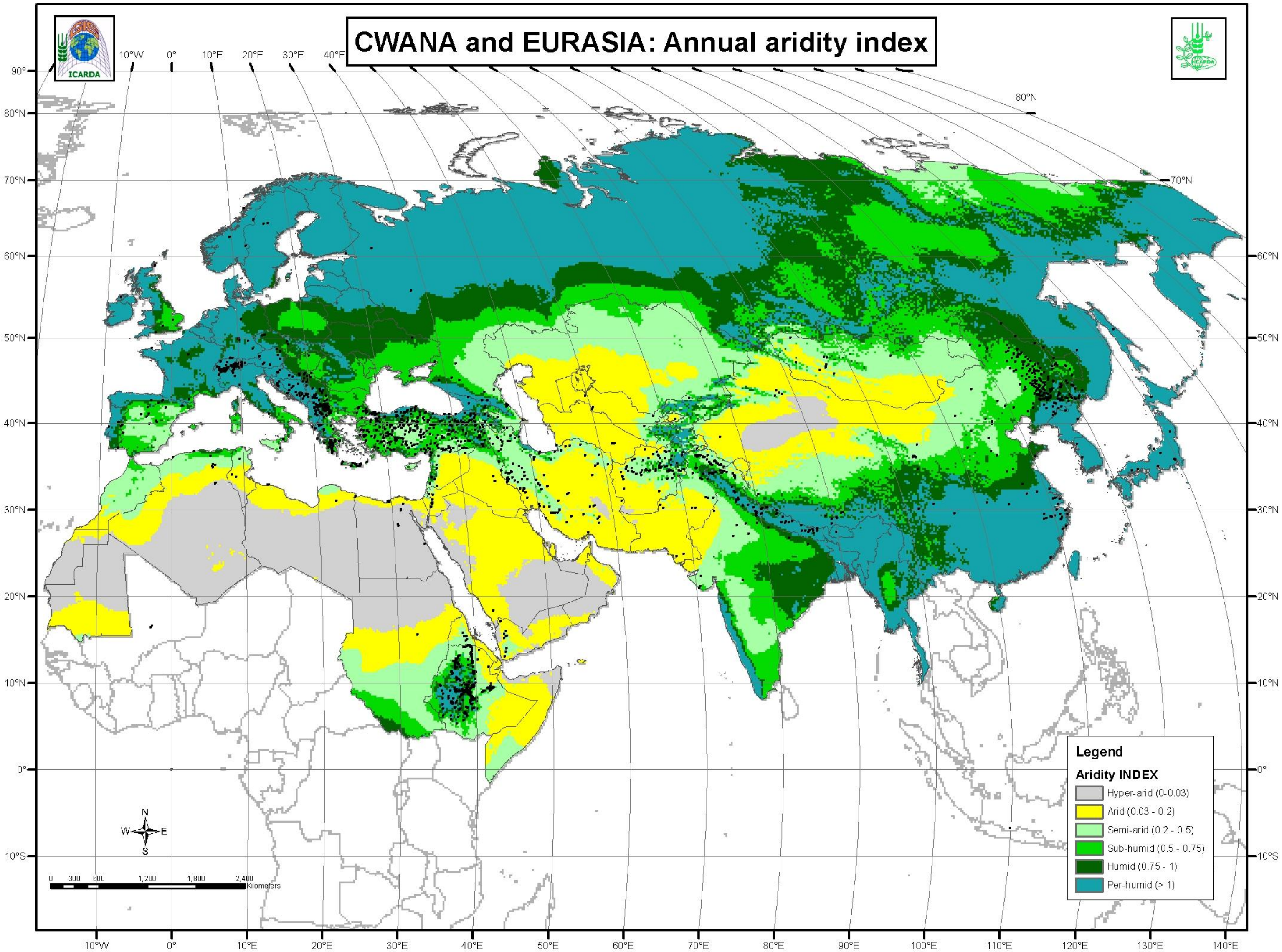


Figure A1.11. Annual aridity index

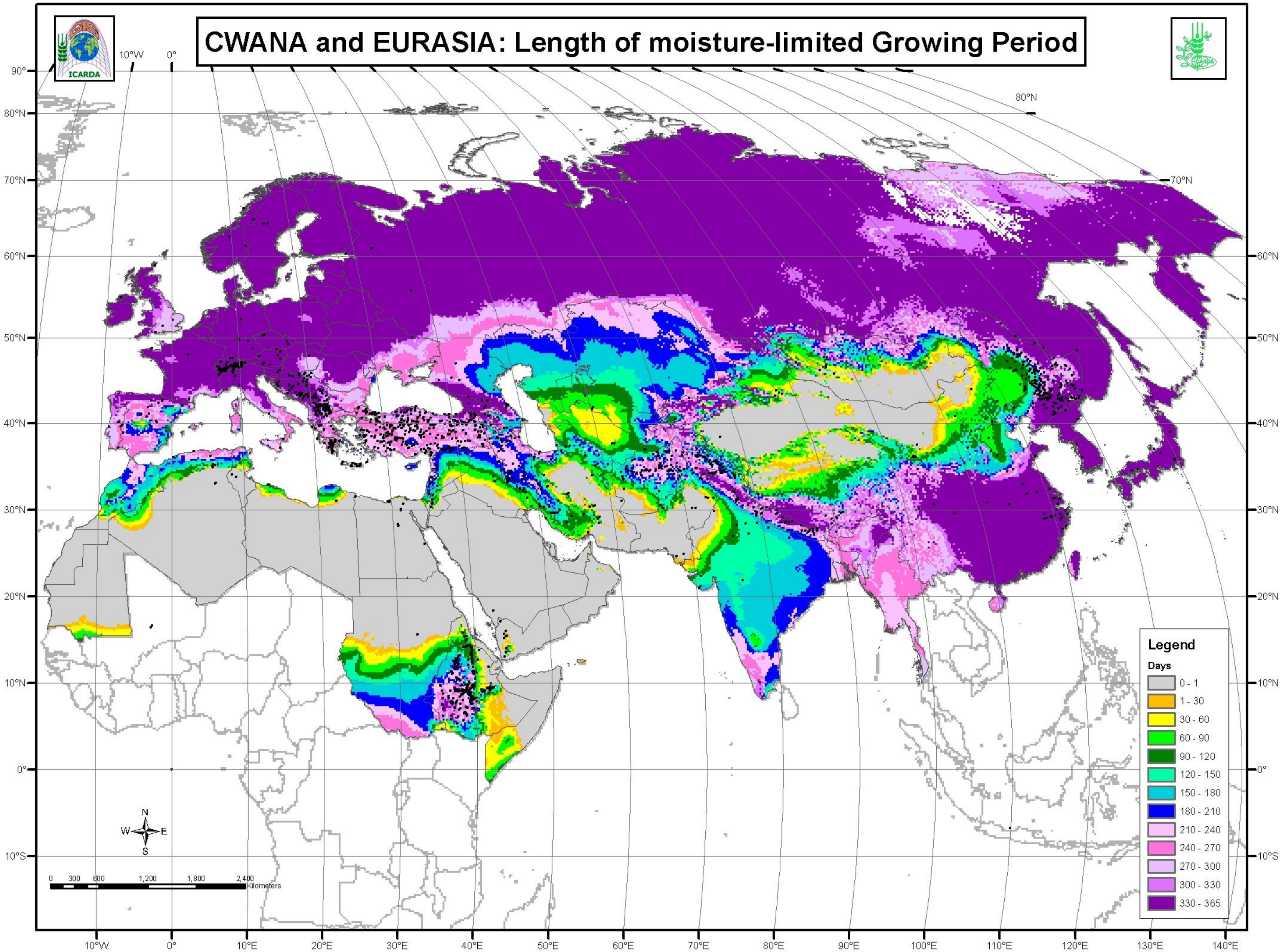


Figure A1.12. Length of the moisture-limited growing period

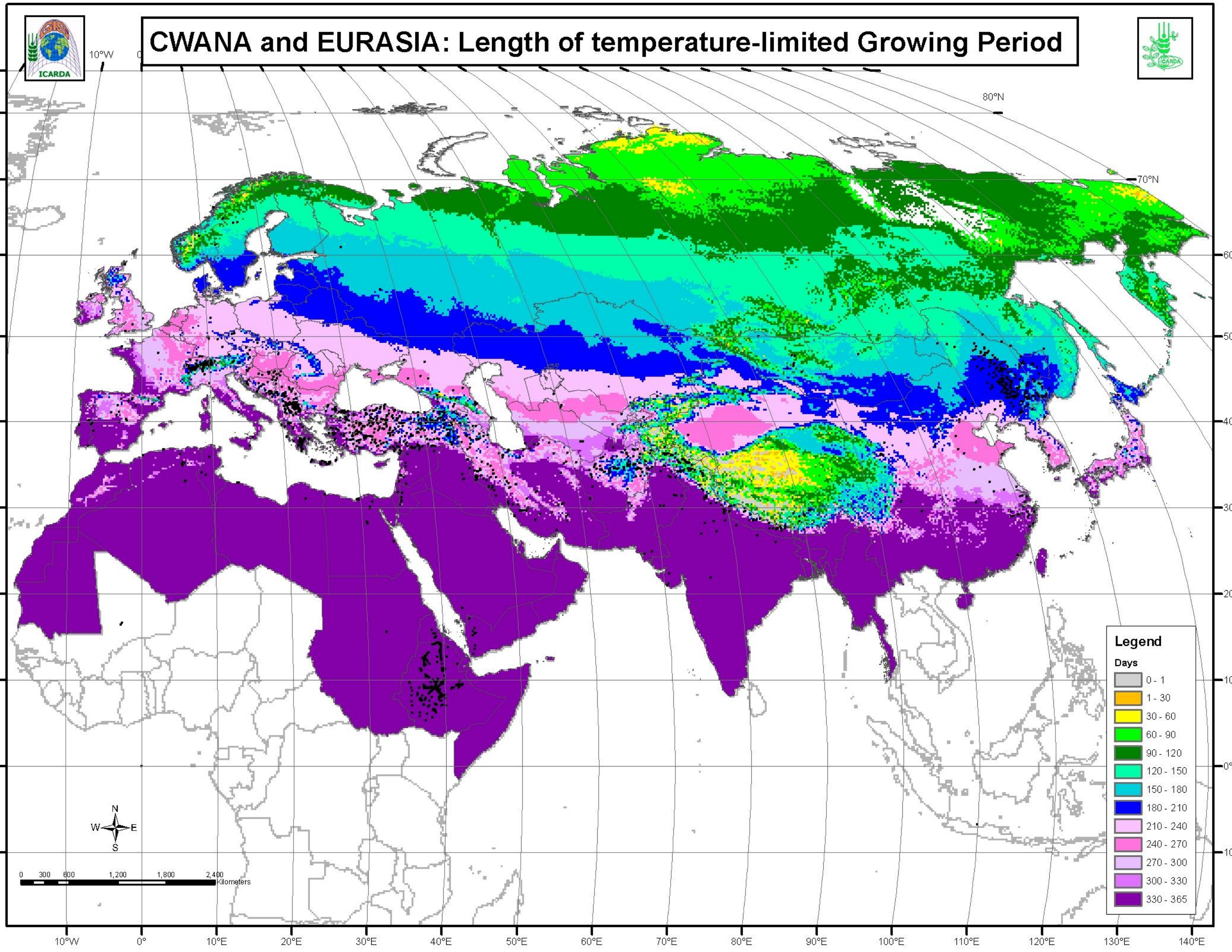


Figure A1.13. Length of the temperature-limited growing period

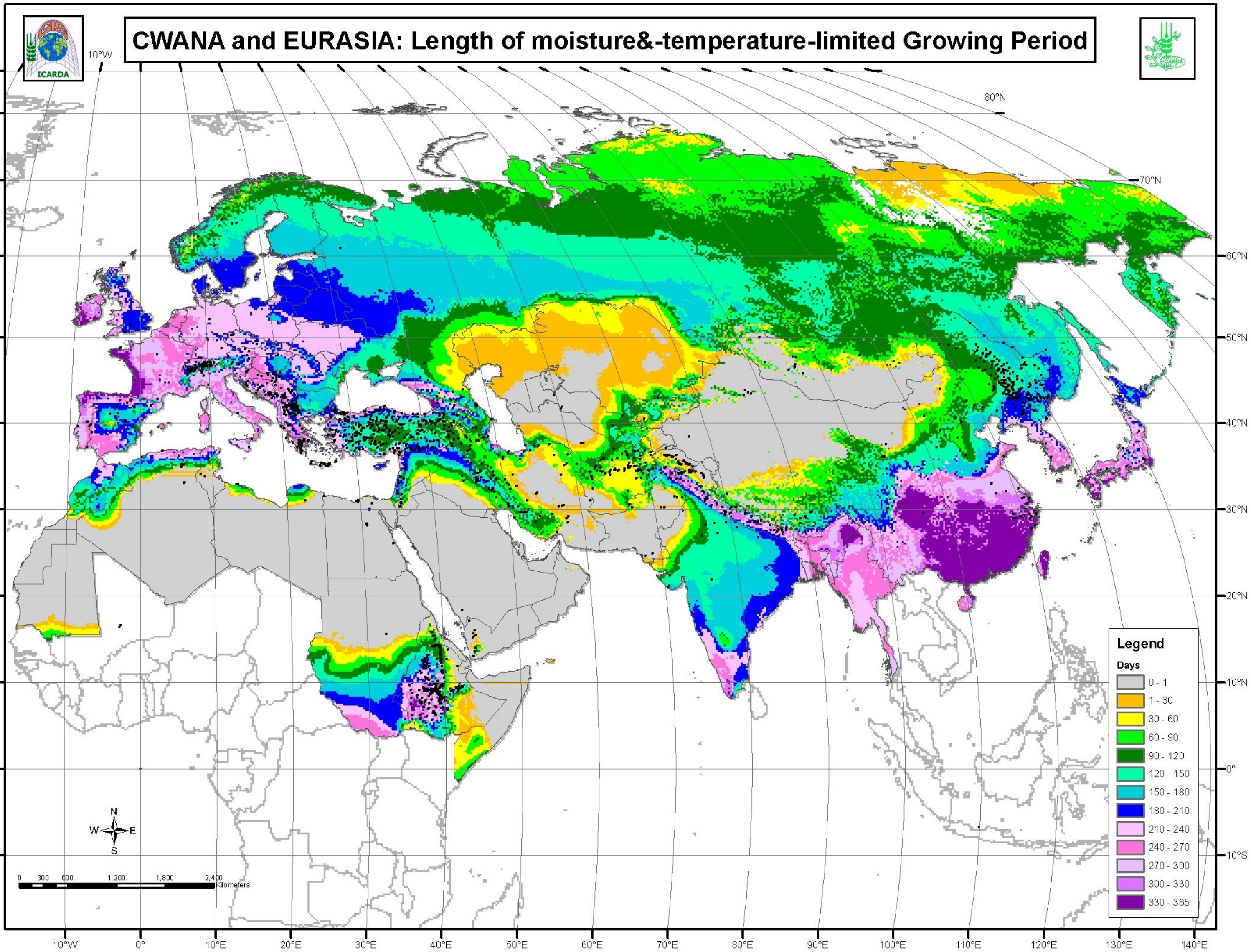


Figure A1.14. Length of the moisture-and temperature-limited growing period

ANNEX 2. SOIL PROPERTY MAPS

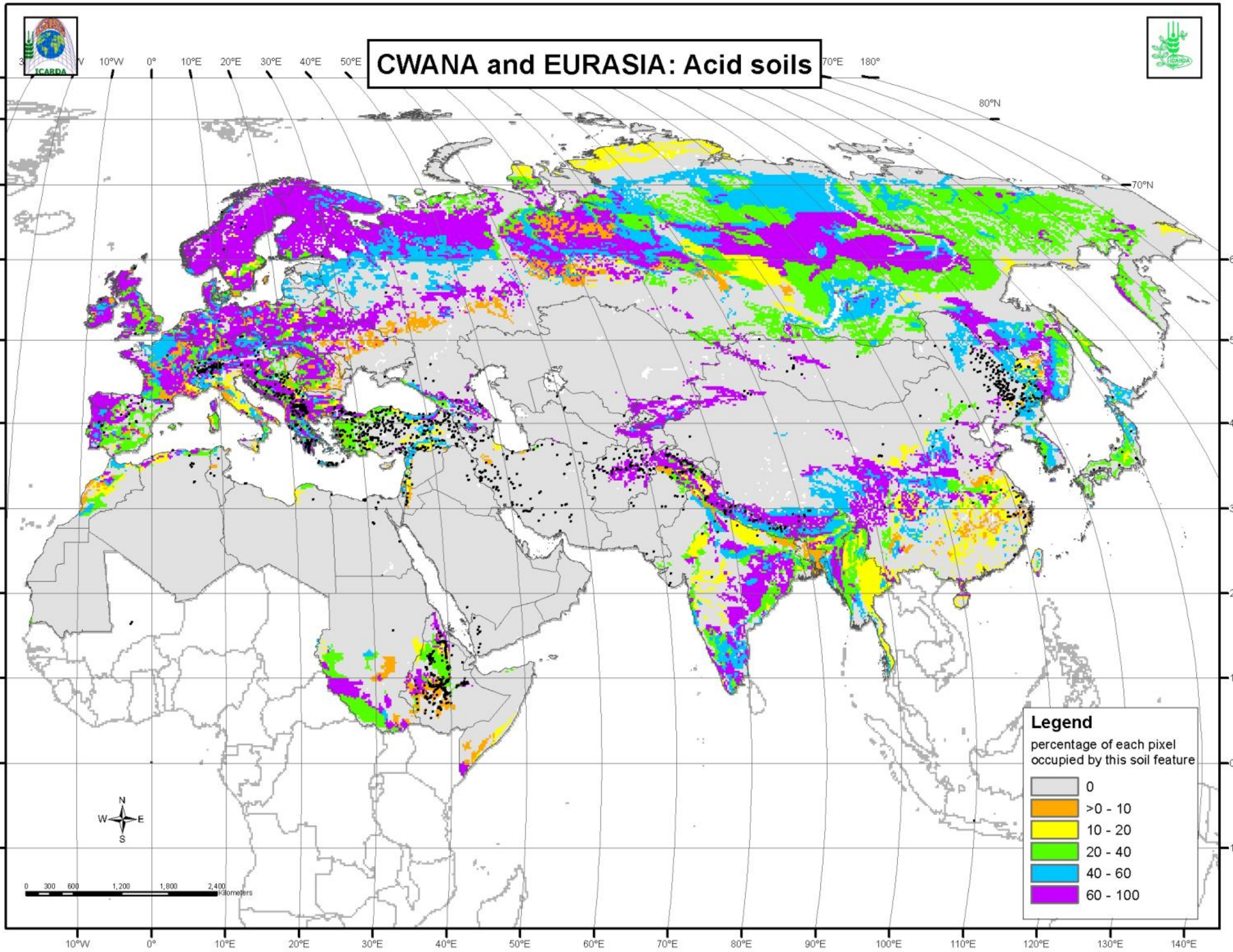


Figure A2.1. Distribution of acid soils

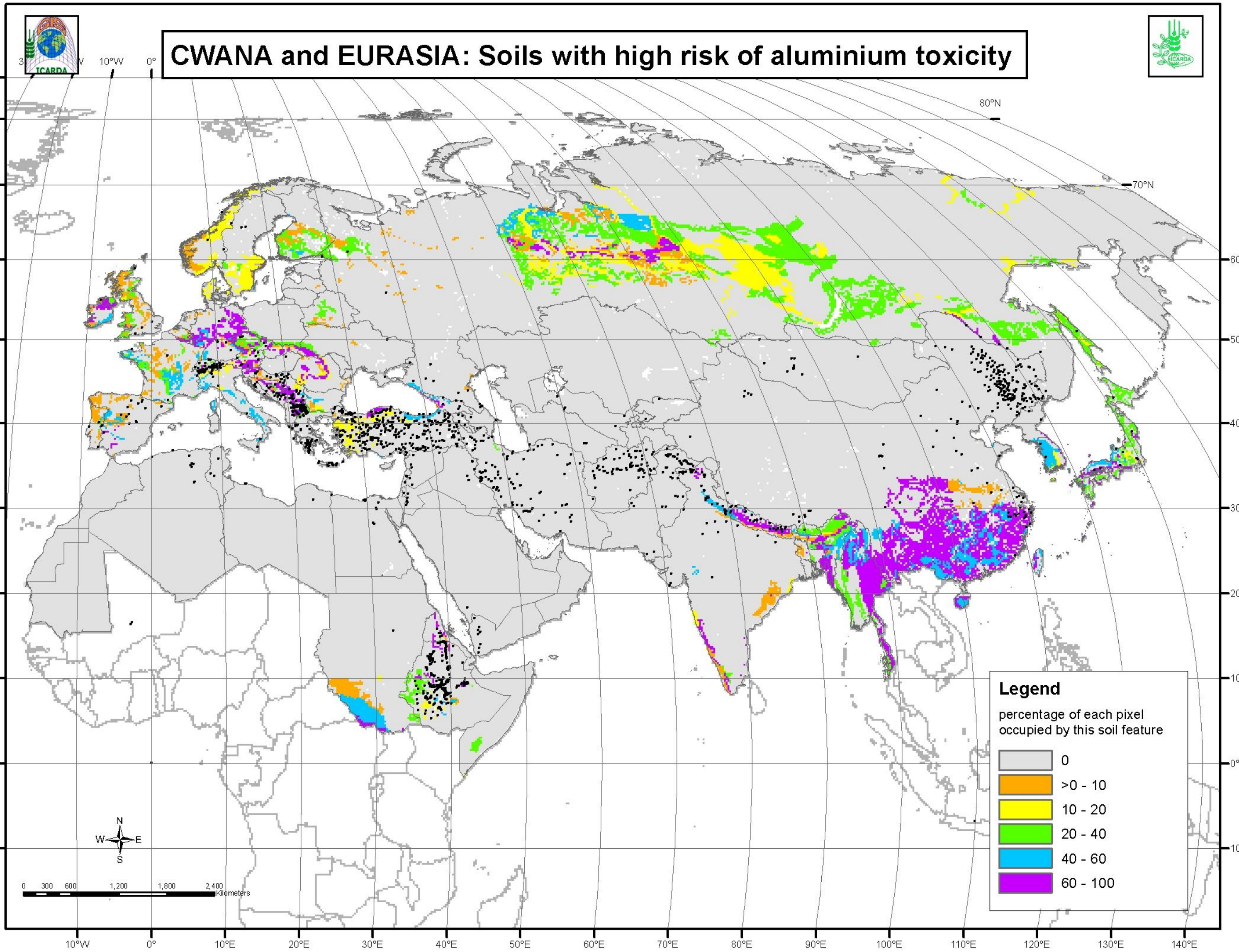


Figure A2.2. Distribution of soils with high risk of aluminium toxicity

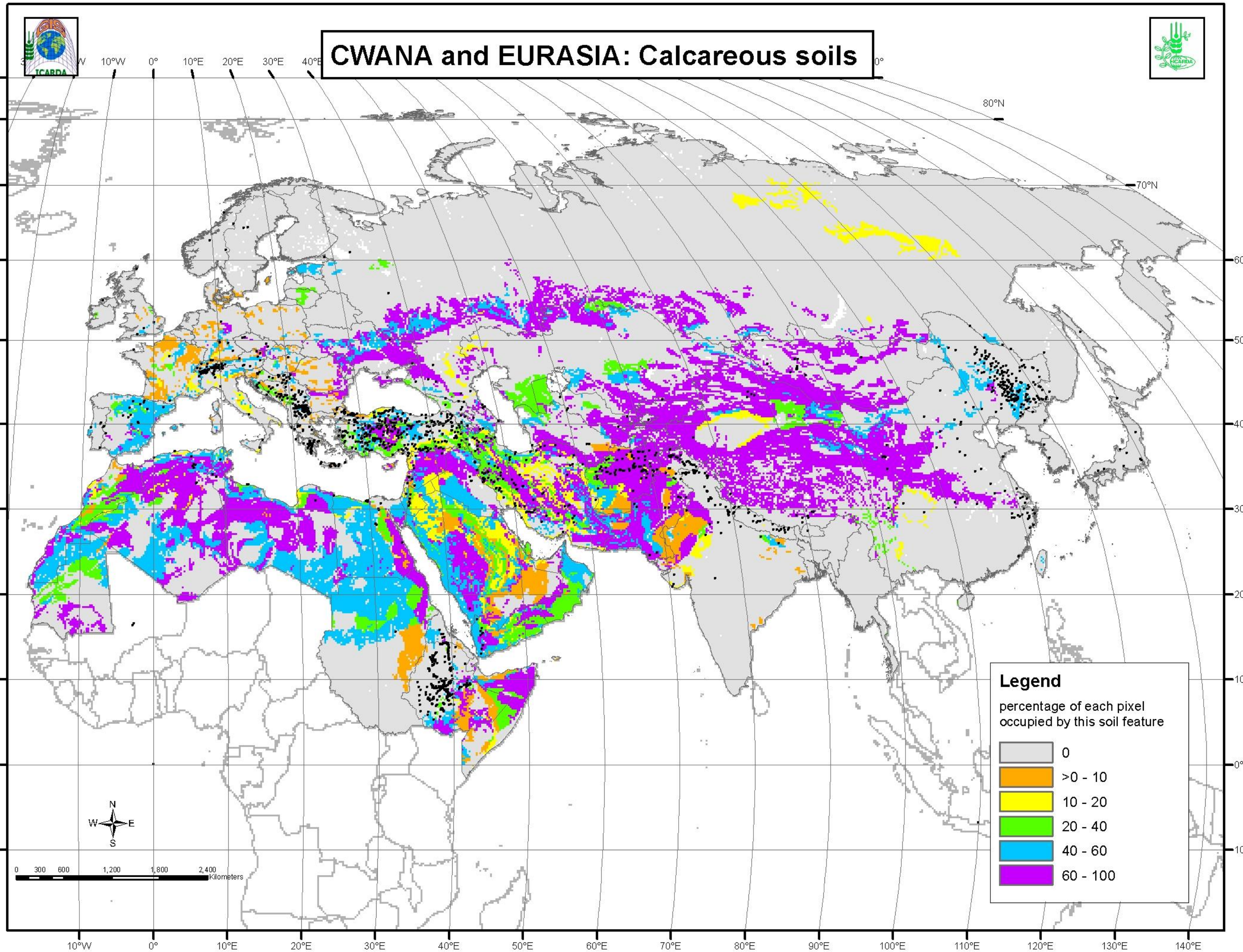


Figure A2.3. Distribution of calcareous soils

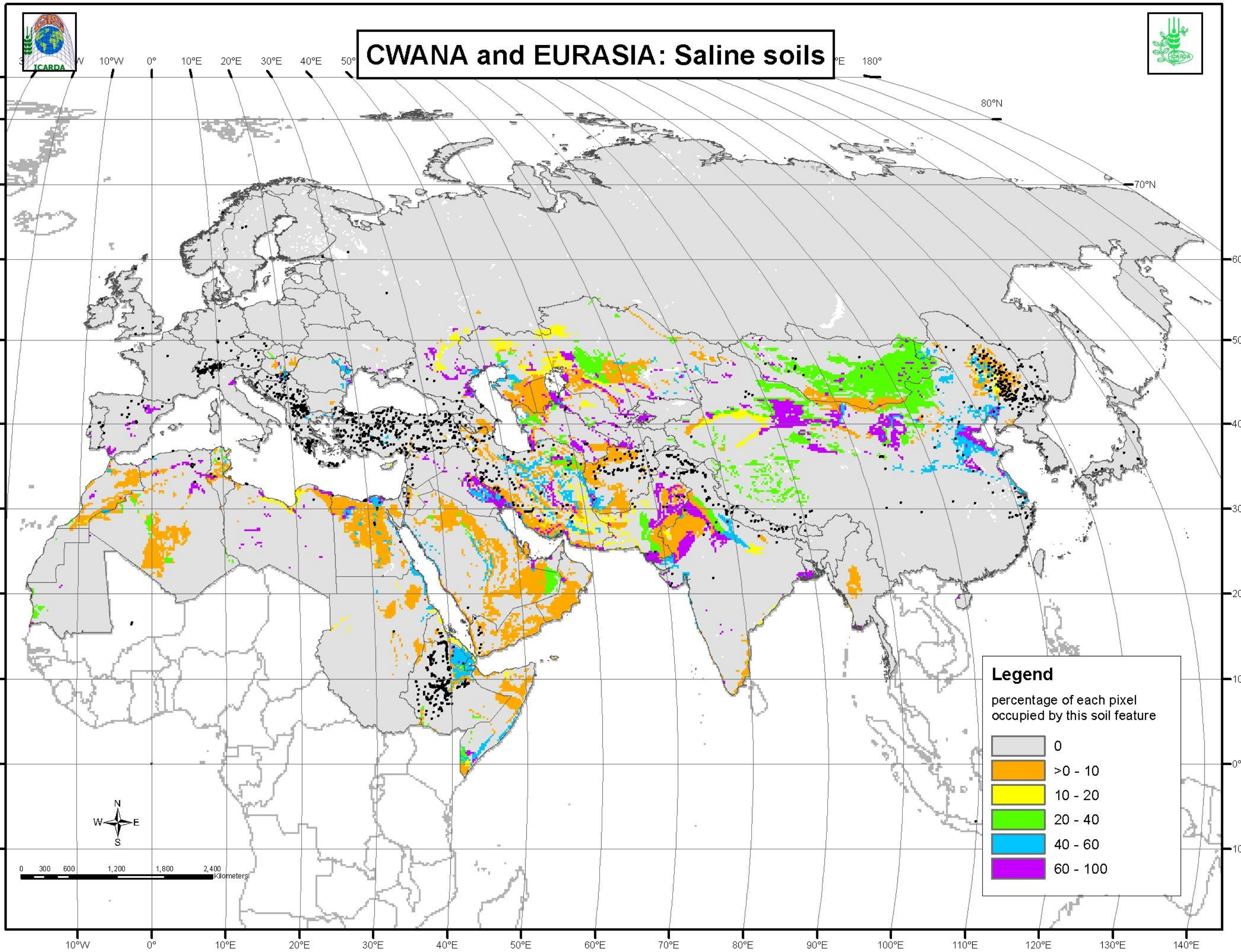


Figure A2.4. Distribution of saline soils

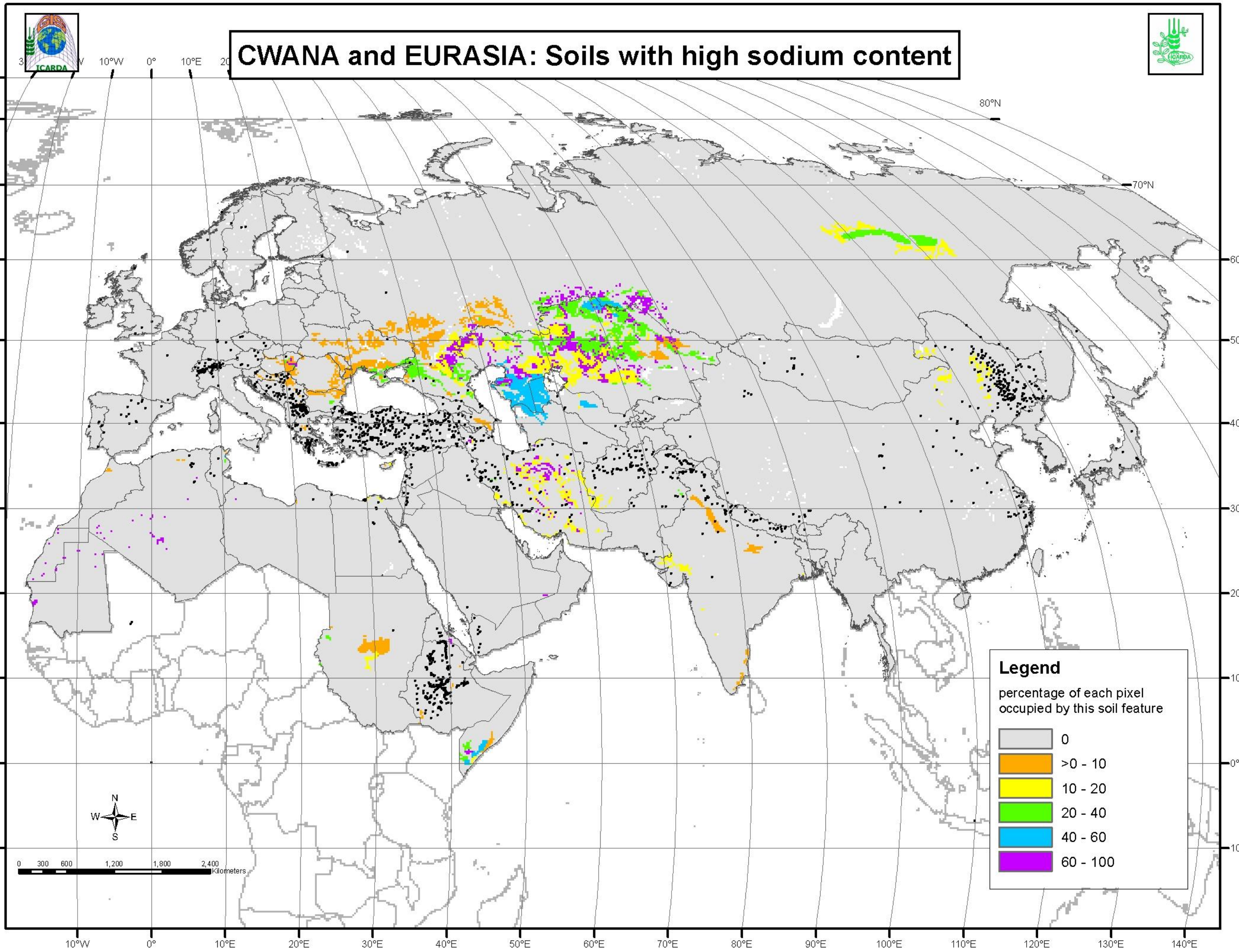


Figure A2.5. Distribution of soils with high sodium content

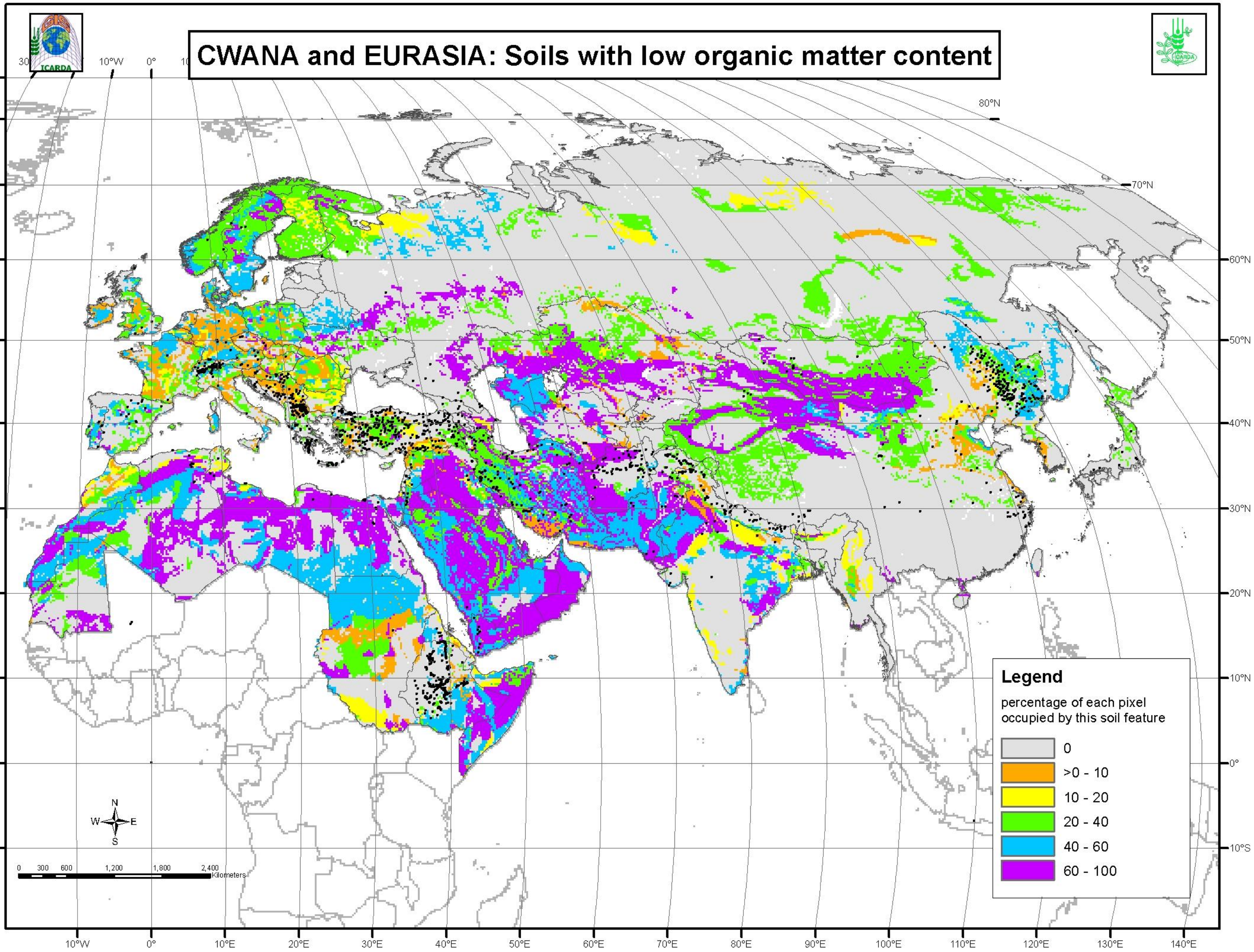


Figure A2.6. Distribution of soils with low organic matter content

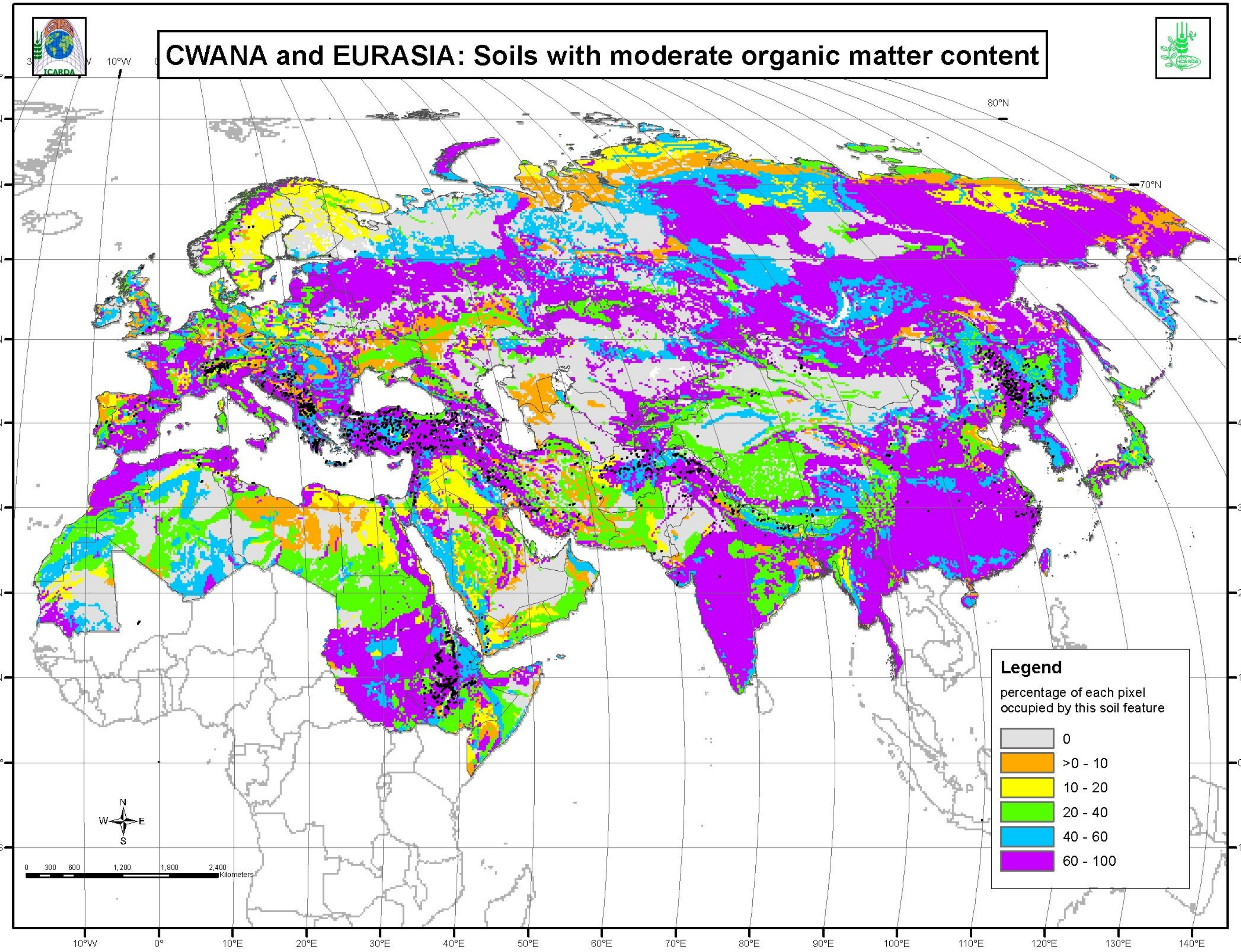


Figure A2.7. Distribution of soils with moderate organic matter content

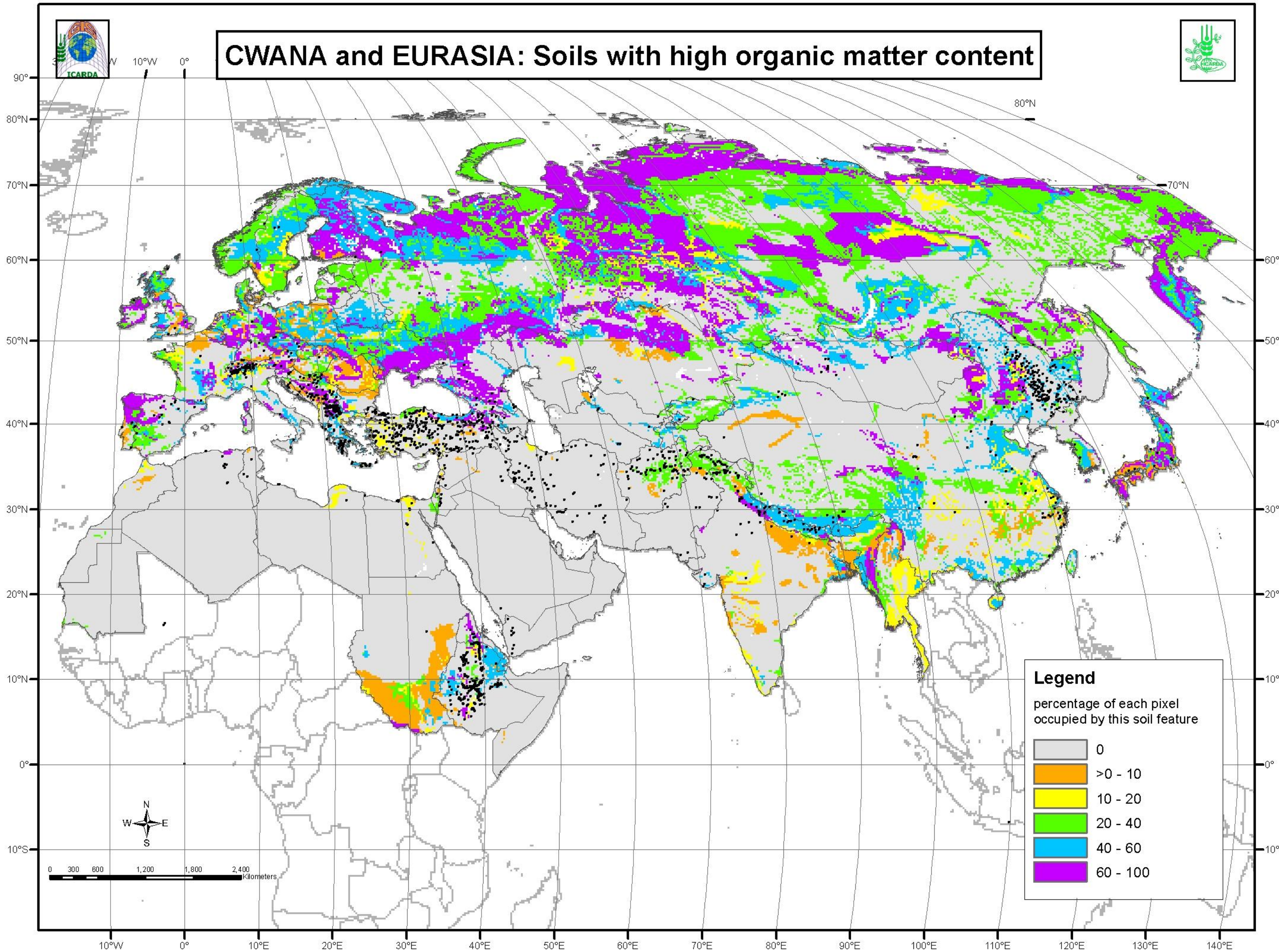


Figure A2.8. Distribution of soils with high organic matter content

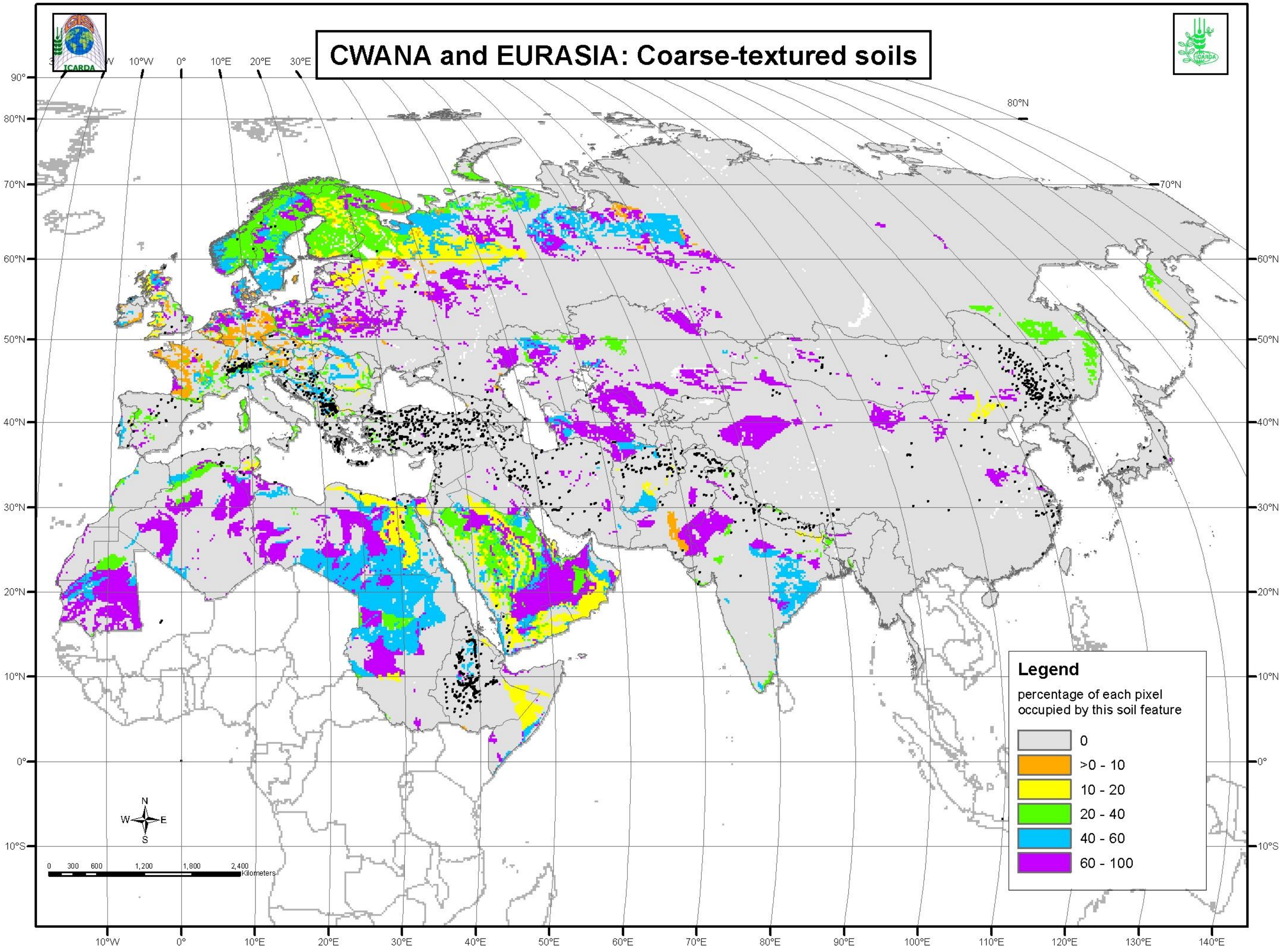
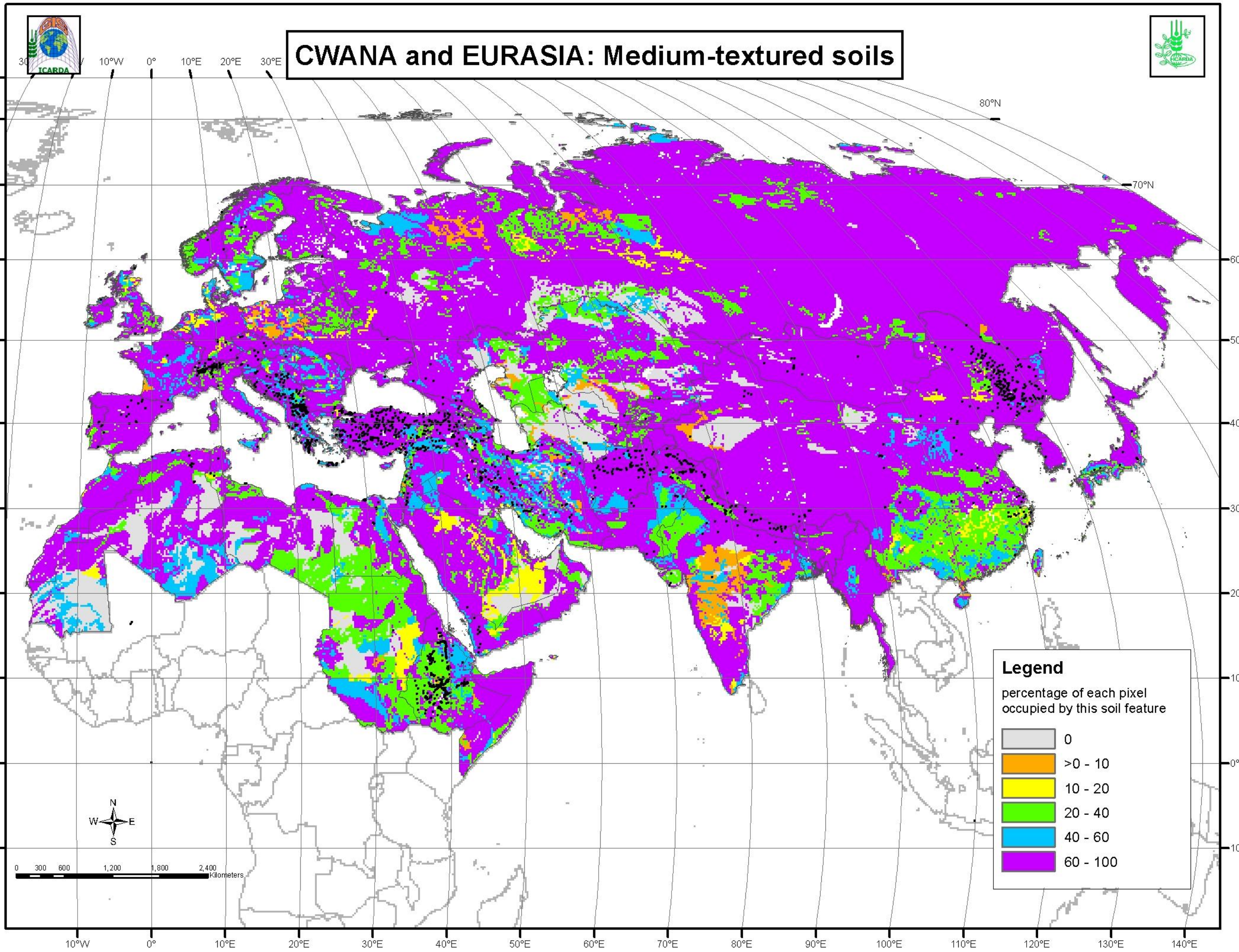


Figure A2.9. Distribution of coarse-textured soils



A2.10. Distribution of medium-textured soils

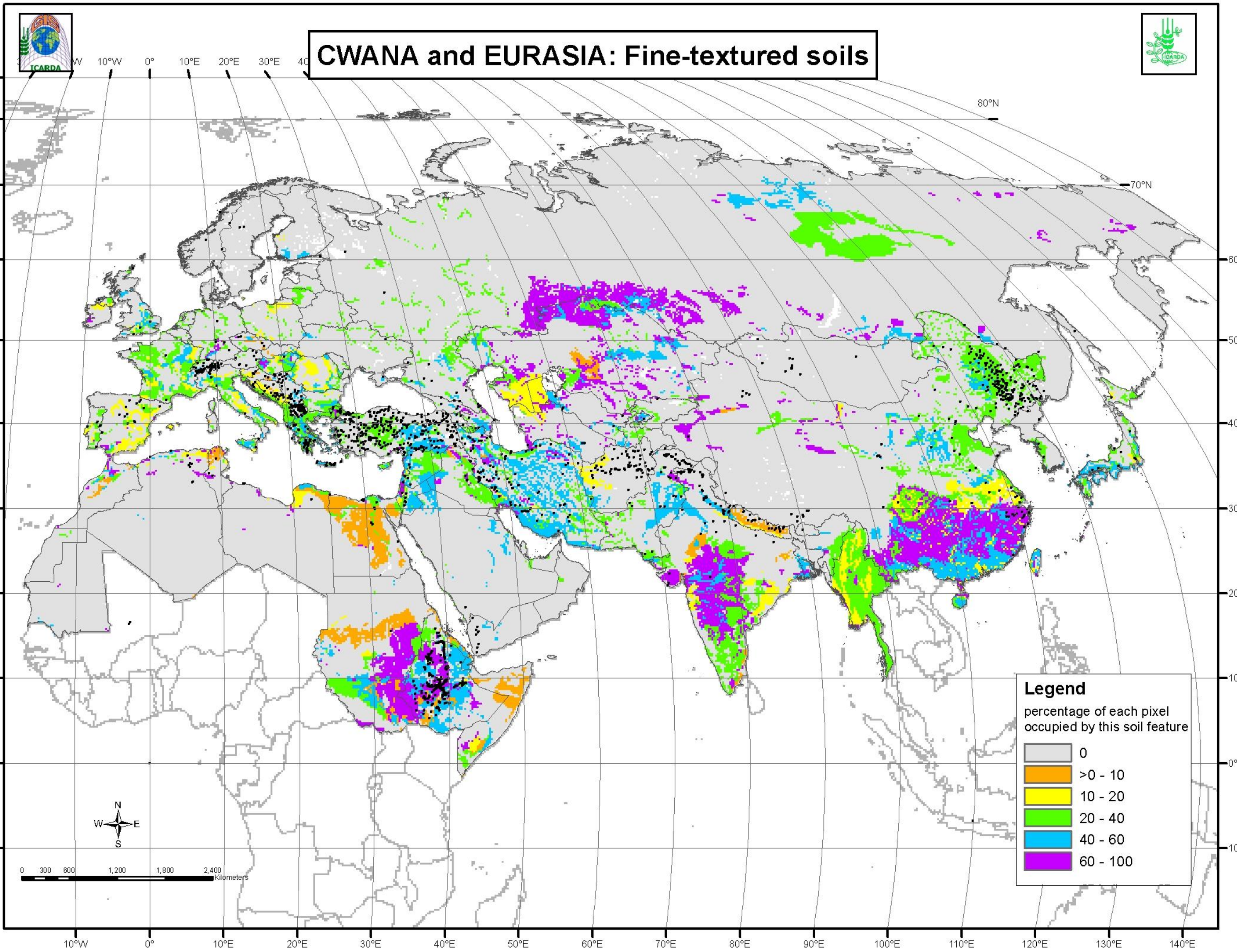


Figure A2.11. Distribution of fine-textured soils

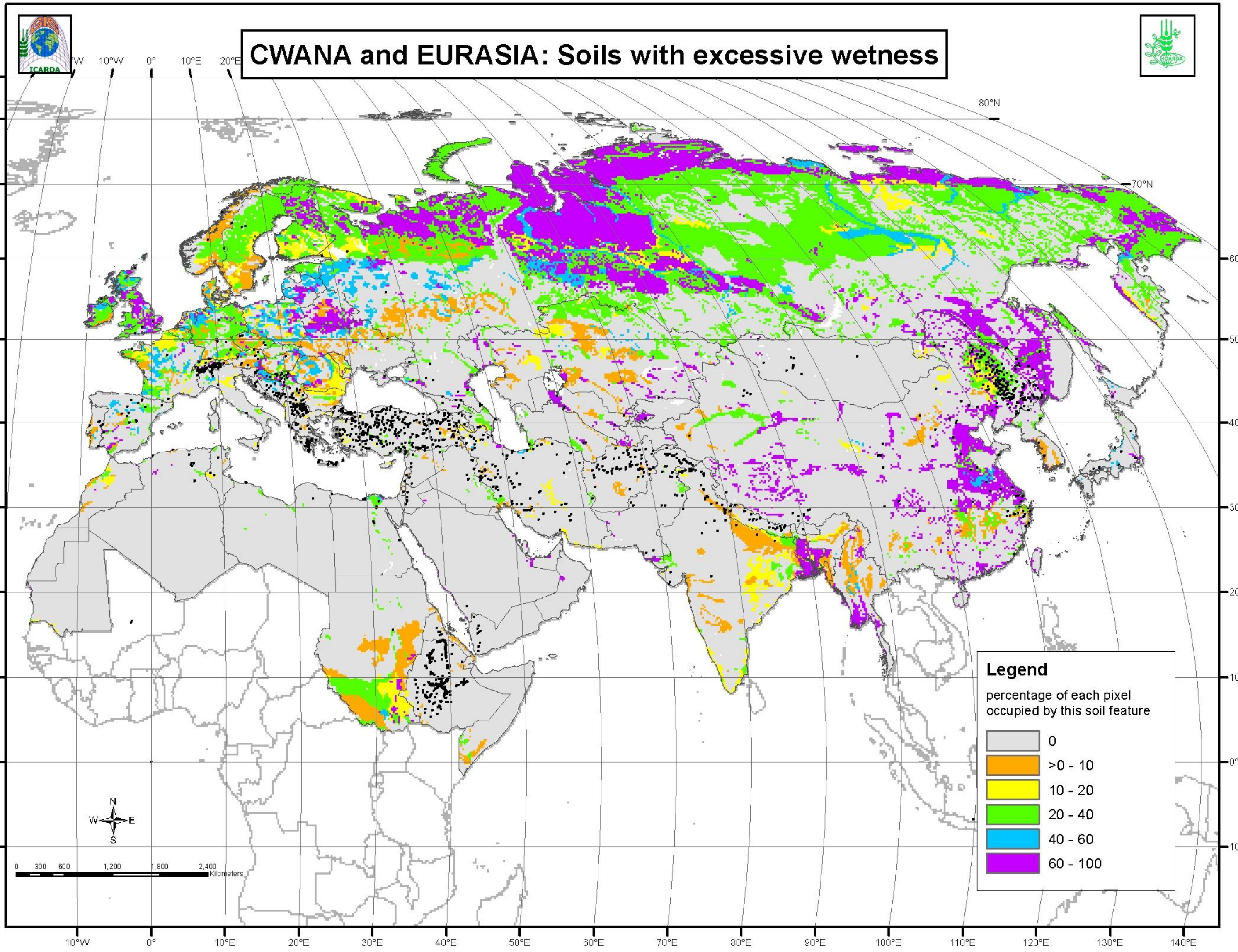


Figure A2.12. Distribution of soils with excessive wetness

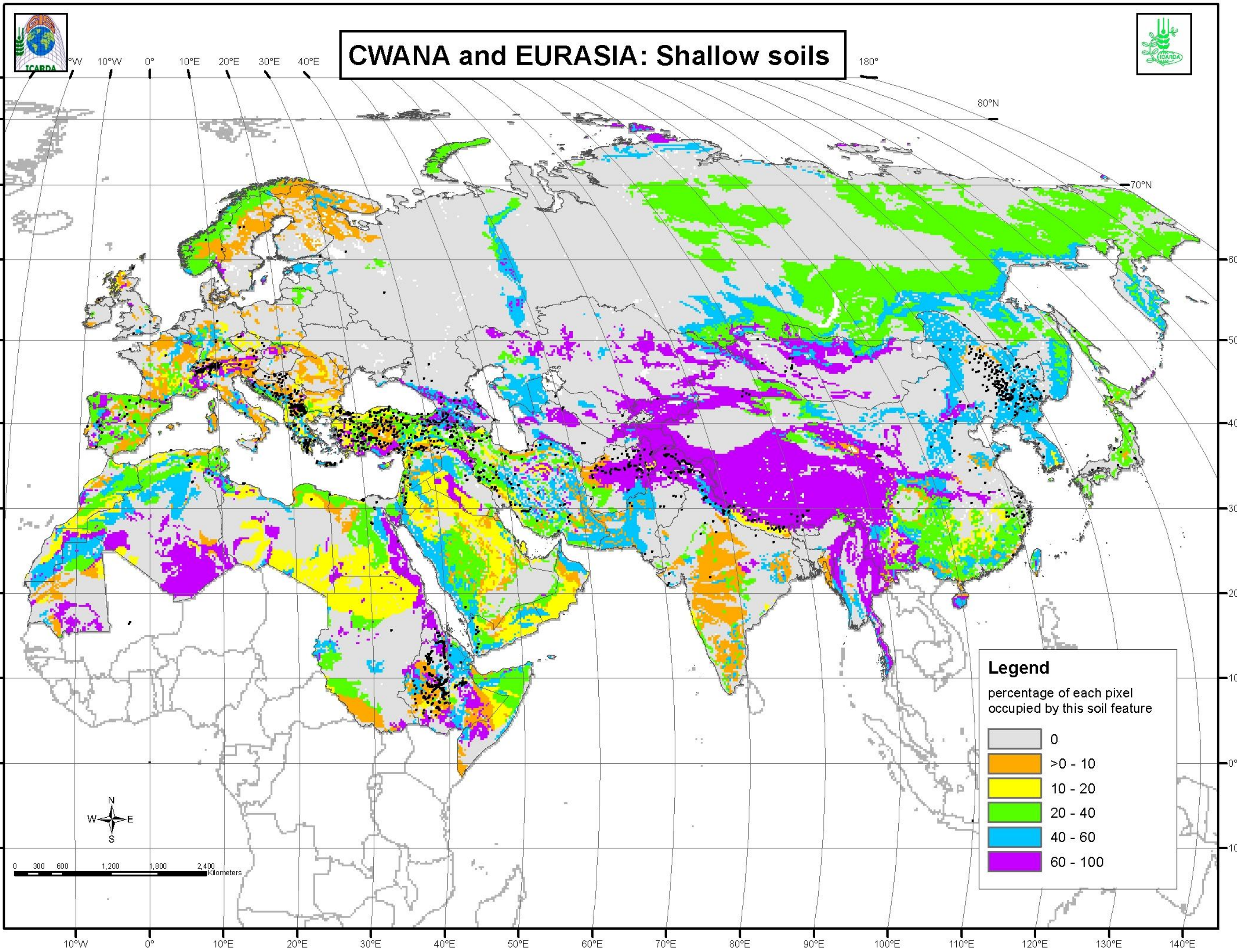


Figure A2.13. Distribution of shallow soils

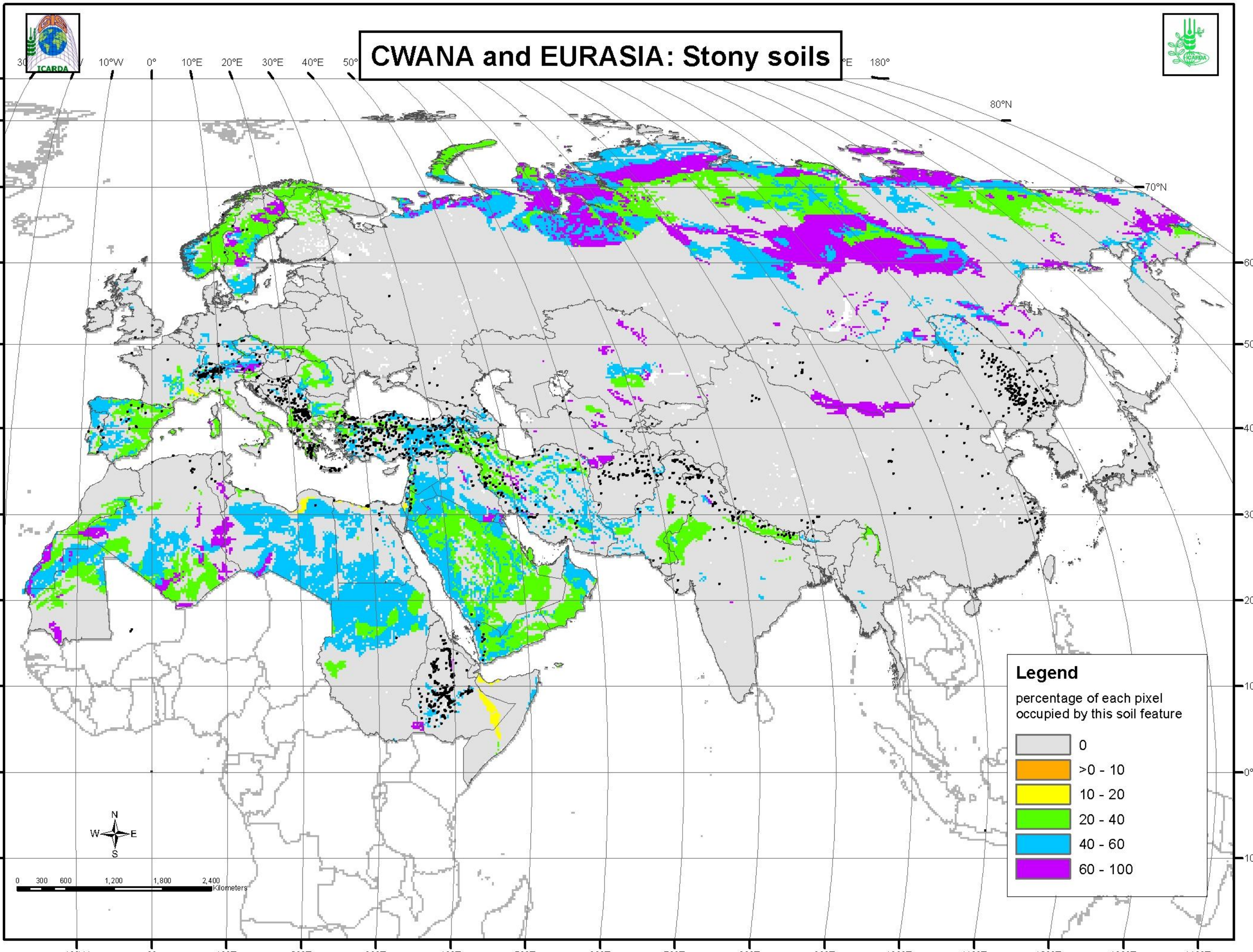


Figure A2.14. Distribution of stony soils

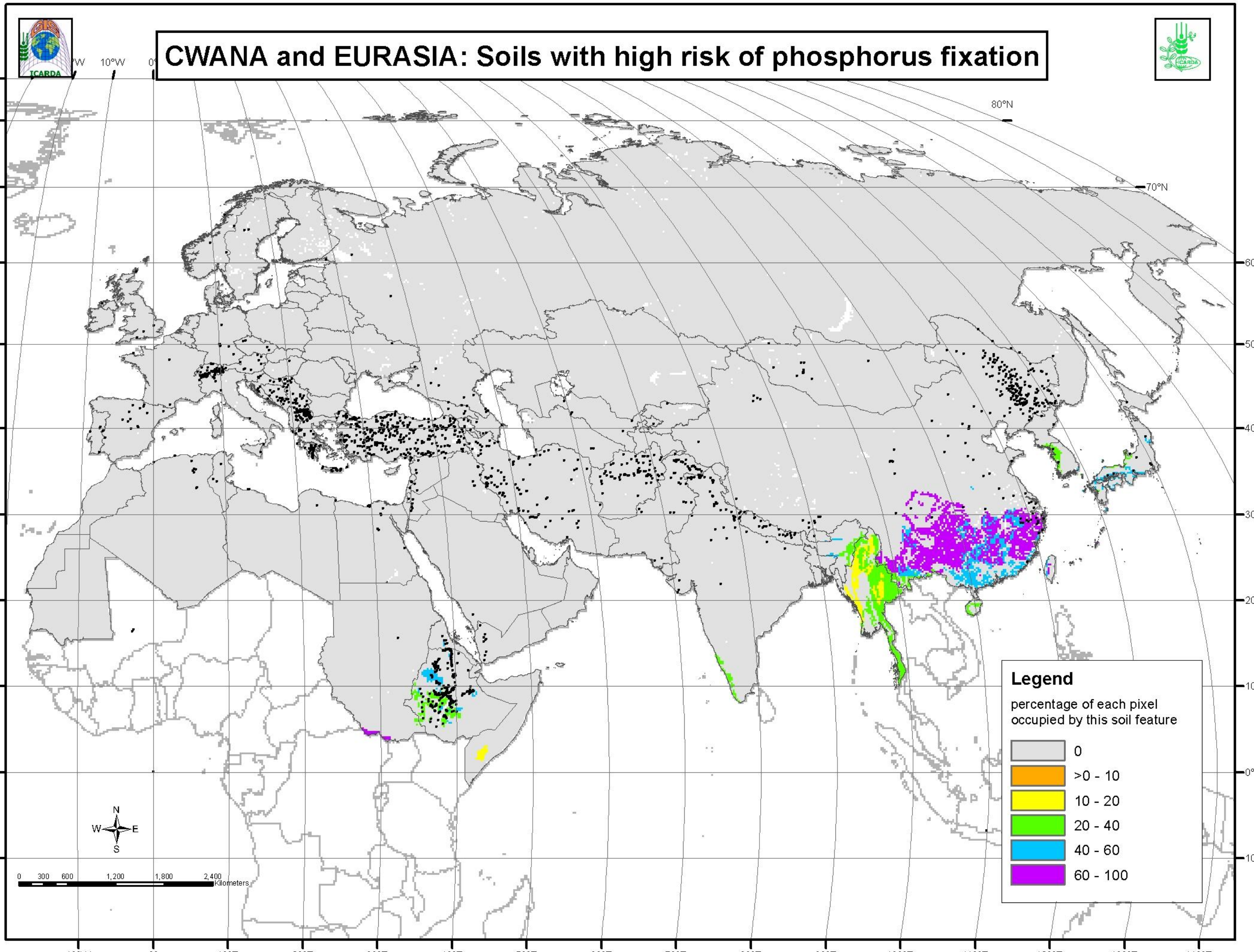


Figure A2.15. Distribution of soils with high risk of phosphorus fixation

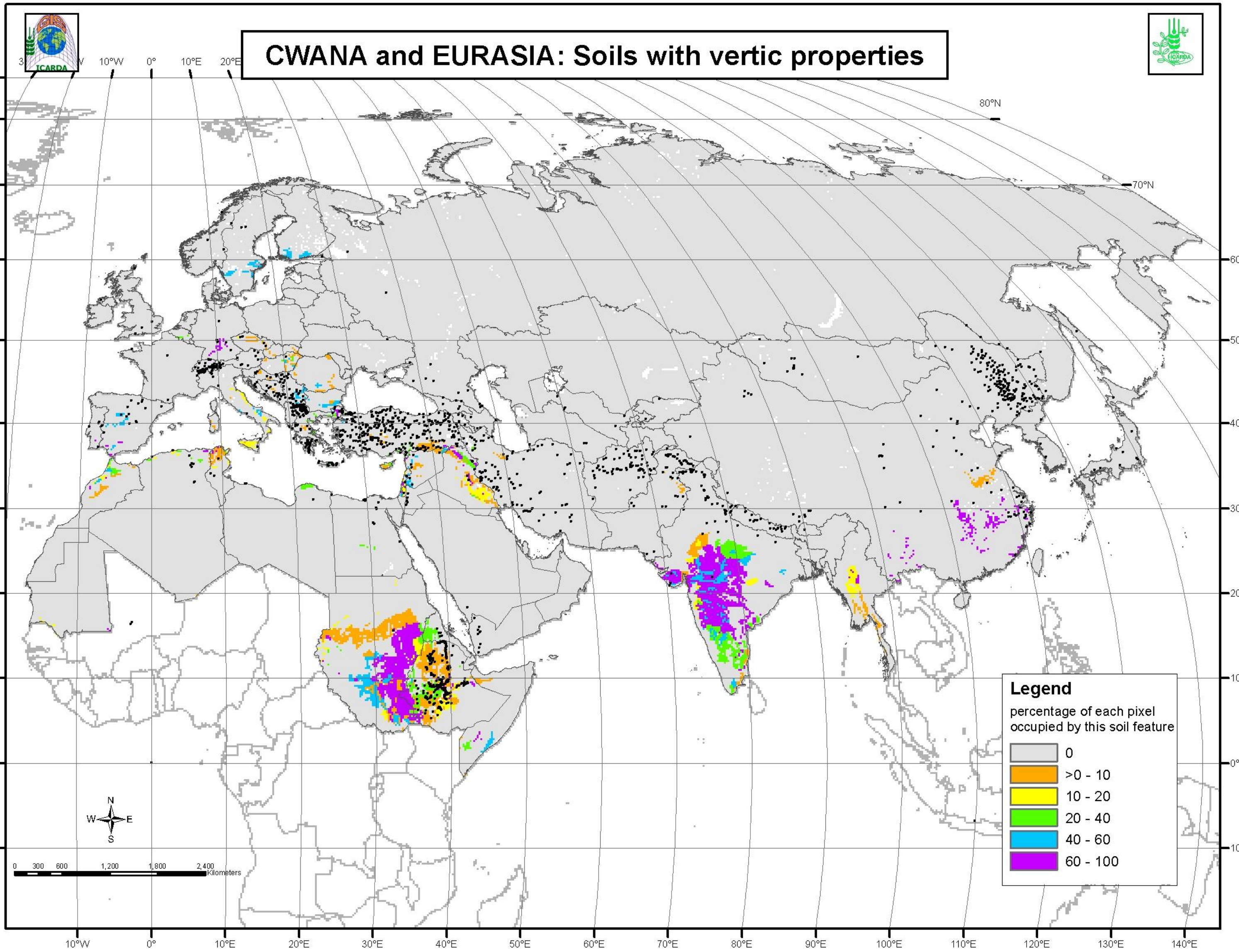


Figure A2.16. Distribution of soils with vertic properties

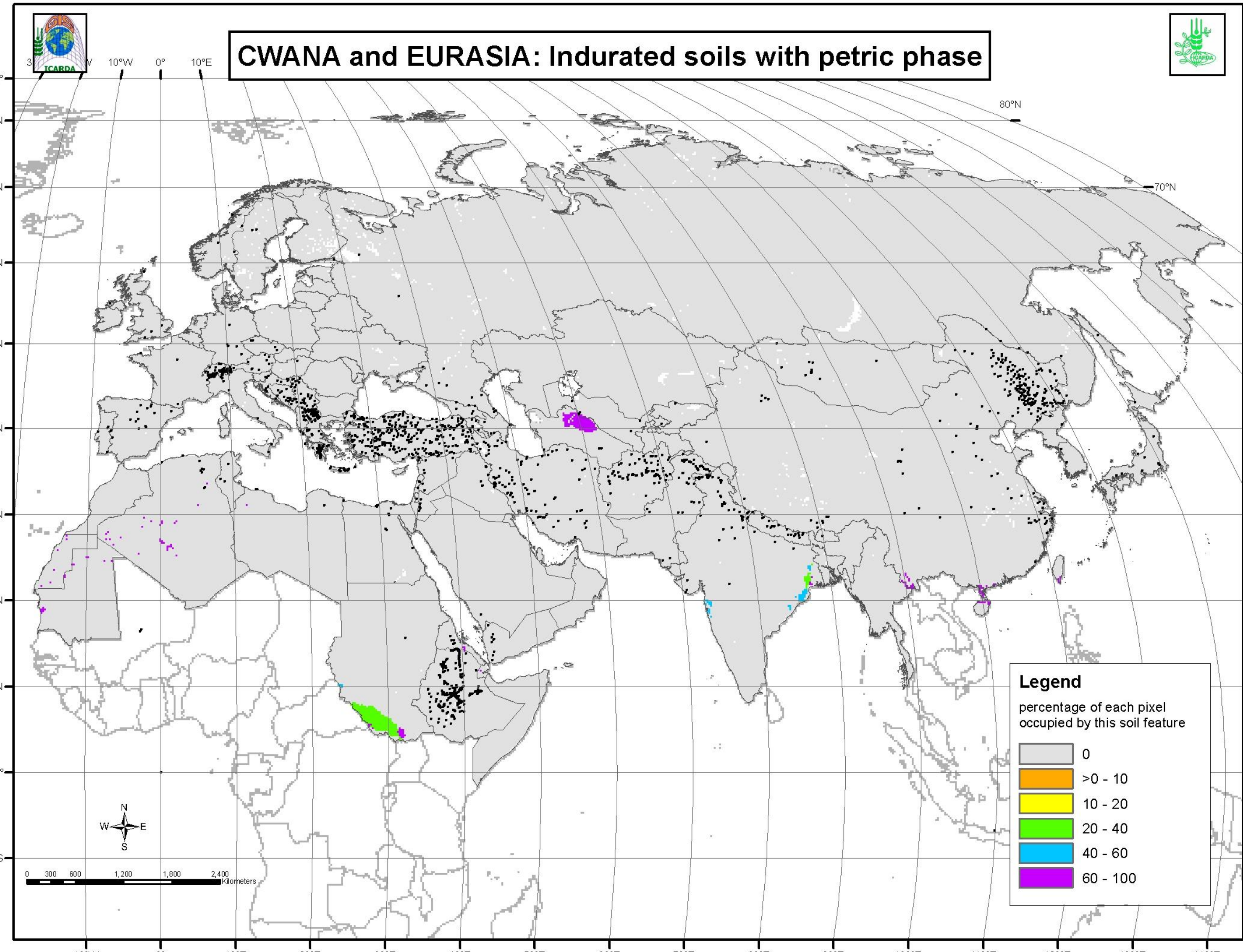


Figure A2.17. Distribution of soils with petric phase

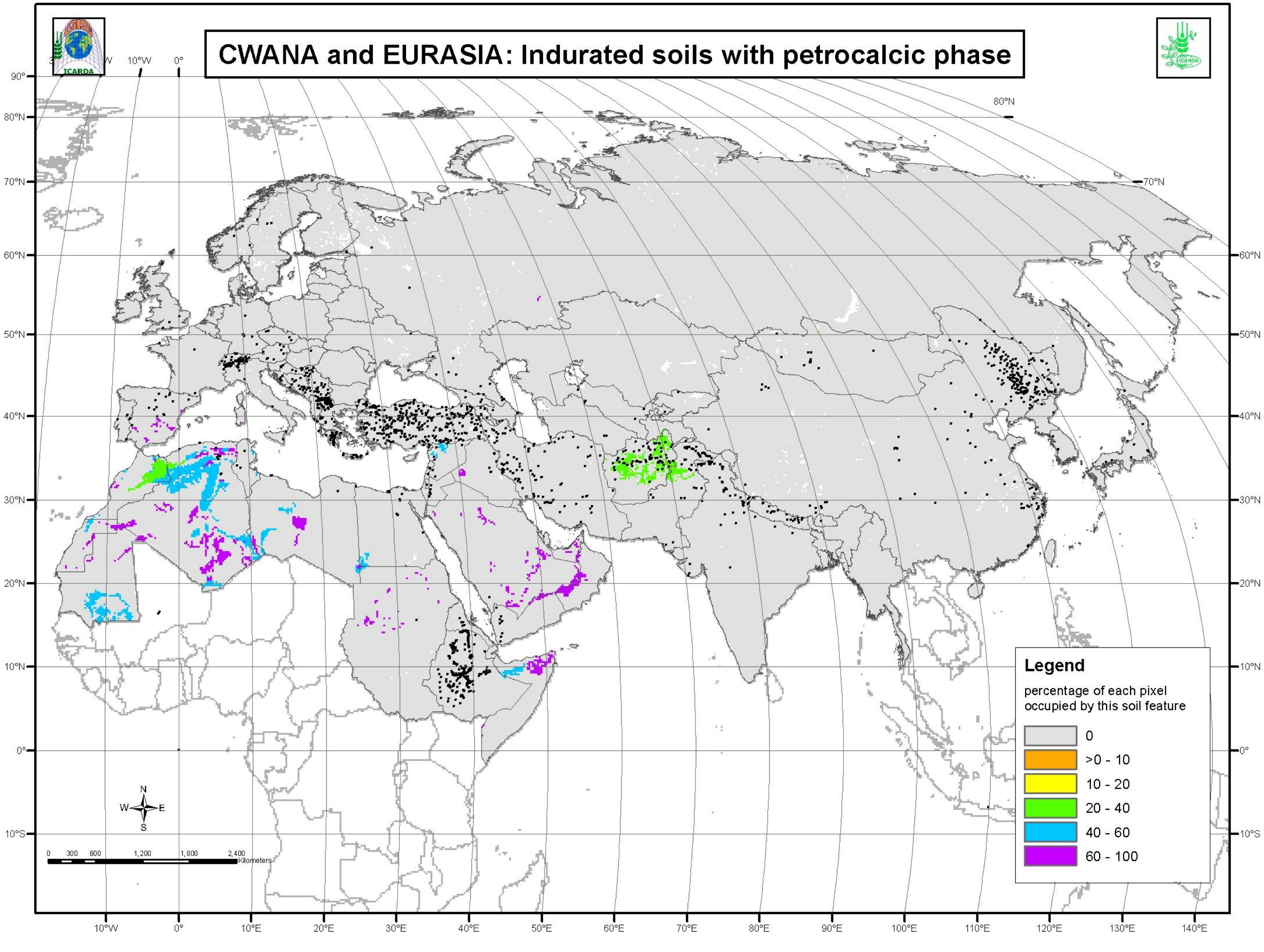


Figure A2.18. Distribution of soils with petrocalcic phase

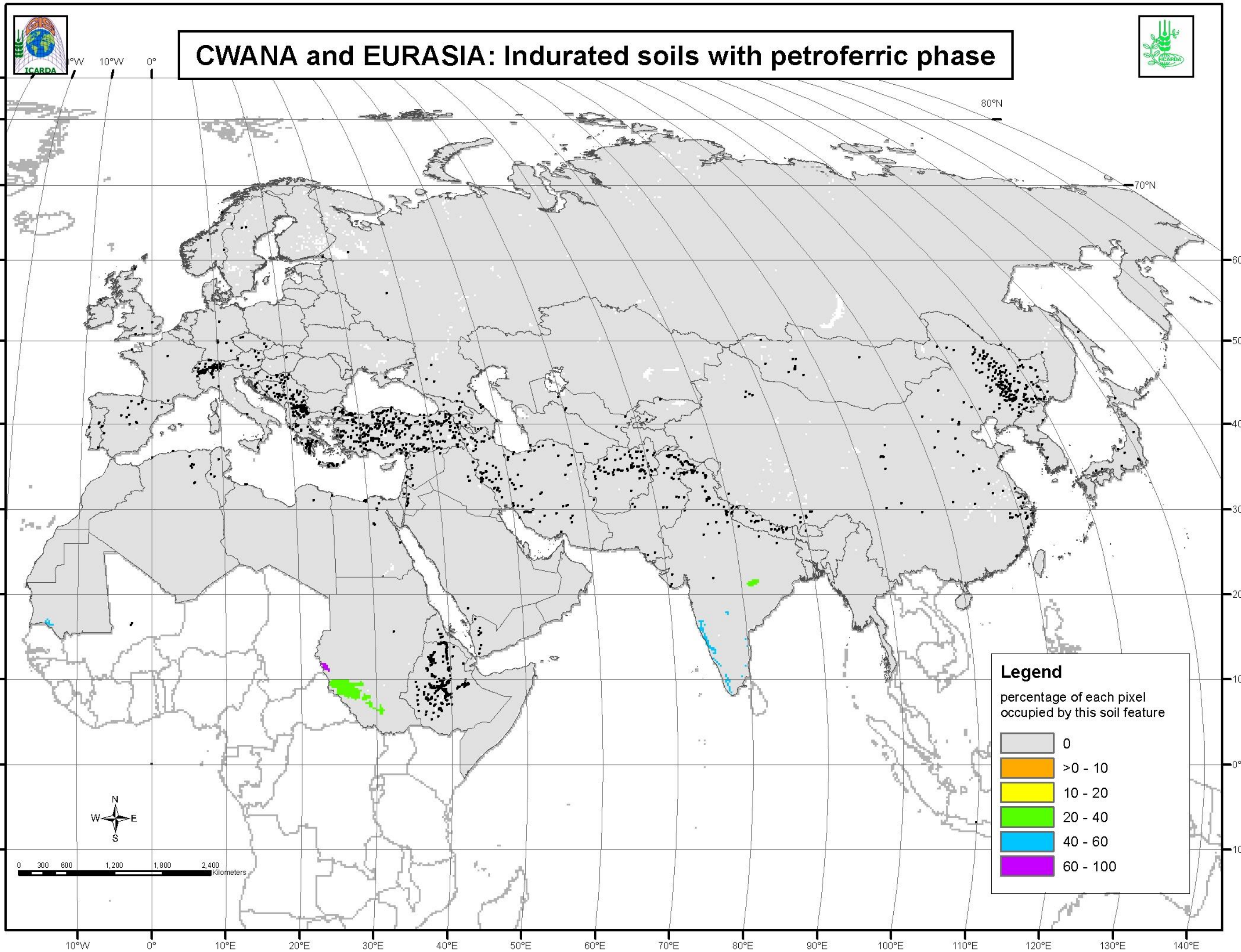


Figure A2.19. Distribution of soils with petroferric phase

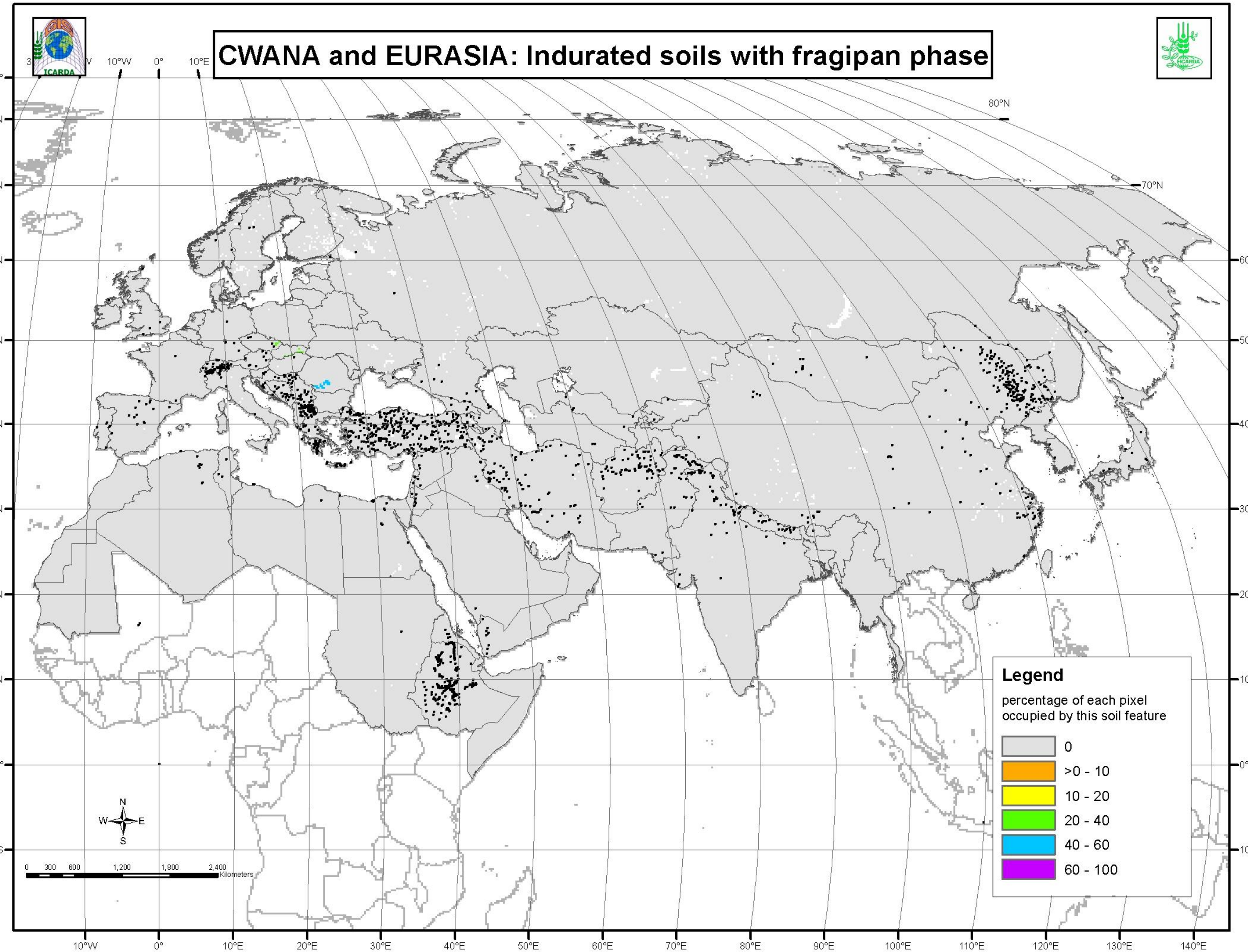


Figure A2.20. Distribution of soils with fragipan phase

ANNEX 3. CLIMATIC DATA SOURCES BY COUNTRY

Table 5. Data sources for precipitation

COUNTRY	Number	Source Data
AFGHANISTAN	13	FAOCLIM. Version 2. World-wide agroclimatic data
ALBANIA	1	FAOCLIM. Version 2. World-wide agroclimatic data
ALGERIA	123	FAOCLIM. Version 2. World-wide agroclimatic data
ARMENIA	50	USSR. Data reference books on climate.
AUSTRIA	1	CAC Global CEAS Summary of Day/Month 1979-cont.
AUSTRIA	14	FAOCLIM. Version 2. World-wide agroclimatic data
AZERBAJAN	50	USSR. Data reference books on climate.
BAHRAIN	1	FAOCLIM. Version 2. World-wide agroclimatic data
BANGLADESH	23	FAOCLIM. Version 2. World-wide agroclimatic data
BELARUS	16	FAOCLIM. Version 2. World-wide agroclimatic data
BELGIUM	2	FAOCLIM. Version 2. World-wide agroclimatic data
BOSNIA/HERZEGOVINA	6	FAOCLIM. Version 2. World-wide agroclimatic data
BULGARIA	10	FAOCLIM. Version 2. World-wide agroclimatic data
CENTRAL_AFRICAN_REP.	2	FAOCLIM. Version 2. World-wide agroclimatic data
CHAD	8	FAOCLIM. Version 2. World-wide agroclimatic data
CHINA	470	FAOCLIM. Version 2. World-wide agroclimatic data
CROATIA	10	FAOCLIM. Version 2. World-wide agroclimatic data
CYPRUS	25	FAOCLIM. Version 2. World-wide agroclimatic data
CZECHIA	5	FAOCLIM. Version 2. World-wide agroclimatic data
DEM.REP.OF_CONGO	2	FAOCLIM. Version 2. World-wide agroclimatic data
DENMARK	2	CAC Global CEAS Summary of Day/Month 1979-cont.
DENMARK	18	FAOCLIM. Version 2. World-wide agroclimatic data
DJIBOUTI	9	FAOCLIM. Version 2. World-wide agroclimatic data
EGYPT	70	FAOCLIM. Version 2. World-wide agroclimatic data
ERITREA	19	FAOCLIM. Version 2. World-wide agroclimatic data
ESTONIA	4	FAOCLIM. Version 2. World-wide agroclimatic data
ETHIOPIA	37	FAOCLIM. Version 2. World-wide agroclimatic data
FINLAND	19	FAOCLIM. Version 2. World-wide agroclimatic data
FRANCE	102	FAOCLIM. Version 2. World-wide agroclimatic data
GEORGIA	89	USSR. Data reference books on climate.
GERMANY_FED.REP.	127	FAOCLIM. Version 2. World-wide agroclimatic data
GIBRALTAR	1	FAOCLIM. Version 2. World-wide agroclimatic data
GREECE	40	FAOCLIM. Version 2. World-wide agroclimatic data
HUNGARY	10	FAOCLIM. Version 2. World-wide agroclimatic data
INDIA	315	FAOCLIM. Version 2. World-wide agroclimatic data
IRAN	126	Iran_MetDept_Climat
IRAQ	37	FAOCLIM. Version 2. World-wide agroclimatic data
IRELAND	17	FAOCLIM. Version 2. World-wide agroclimatic data
ISRAEL	32	FAOCLIM. Version 2. World-wide agroclimatic data
ITALY	72	FAOCLIM. Version 2. World-wide agroclimatic data
JAPAN	228	FAOCLIM. Version 2. World-wide agroclimatic data
JORDAN	43	FAOCLIM. Version 2. World-wide agroclimatic data
KAZAKHSTAN	123	USSR. Data reference books on climate.
KENYA	6	FAOCLIM. Version 2. World-wide agroclimatic data
NORTH KOREA	9	FAOCLIM. Version 2. World-wide agroclimatic data
SOUTH KOREA	64	FAOCLIM. Version 2. World-wide agroclimatic data
KYRGYZSTAN	69	USSR. Data reference books on climate.
LATVIA	6	FAOCLIM. Version 2. World-wide agroclimatic data
LEBANON	31	USSR. Data reference books on climate.

LIBYA	26	FAOCLIM. Version 2. World-wide agroclimatic data
LIECHTENSTEIN	1	CAC Global CEAS Summary of Day/Month 1979-cont.
LITHUANIA	4	FAOCLIM. Version 2. World-wide agroclimatic data
LUXEMBOURG	2	FAOCLIM. Version 2. World-wide agroclimatic data
MACEDONIA	3	FAOCLIM. Version 2. World-wide agroclimatic data
MALI	15	FAOCLIM. Version 2. World-wide agroclimatic data
Malta	1	FAOCLIM. Version 2. World-wide agroclimatic data
MAURITANIA	32	FAOCLIM. Version 2. World-wide agroclimatic data
MONGOLIA	46	FAOCLIM. Version 2. World-wide agroclimatic data
MOROCCO	42	FAOCLIM. Version 2. World-wide agroclimatic data
MYANMAR	31	FAOCLIM. Version 2. World-wide agroclimatic data
NEPAL	93	FAOCLIM. Version 2. World-wide agroclimatic data
NETHERLANDS	7	FAOCLIM. Version 2. World-wide agroclimatic data
NIGER	2	FAOCLIM. Version 2. World-wide agroclimatic data
NORWAY	1	FAOCLIM. Version 2. World-wide agroclimatic data
NORWAY	18	FAOCLIM. Version 2. World-wide agroclimatic data
OMAN	52	FAOCLIM. Version 2. World-wide agroclimatic data
PAKISTAN	113	FAOCLIM. Version 2. World-wide agroclimatic data
POLAND	30	FAOCLIM. Version 2. World-wide agroclimatic data
PORTUGAL	30	FAOCLIM. Version 2. World-wide agroclimatic data
QATAR	28	FAOCLIM. Version 2. World-wide agroclimatic data
ROMANIA	17	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	386	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	86	LAND RESOURCES OF RUSSIA CD-ROM
SAUDI ARABIA	39	FAOCLIM. Version 2. World-wide agroclimatic data
SENEGAL	16	FAOCLIM. Version 2. World-wide agroclimatic data
SERBIA&MONTENEGRO	9	FAOCLIM. Version 2. World-wide agroclimatic data
SLOVAKIA	4	FAOCLIM. Version 2. World-wide agroclimatic data
SLOVENIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
SOMALIA	27	FAOCLIM. Version 2. World-wide agroclimatic data
SPAIN	82	FAOCLIM. Version 2. World-wide agroclimatic data
SUDAN	152	FAOCLIM. Version 2. World-wide agroclimatic data
SWEDEN	1	CAC Global CEAS Summary of Day/Month 1979-cont.
SWEDEN	46	FAOCLIM. Version 2. World-wide agroclimatic data
SWITZERLAND	1	CAC Global CEAS Summary of Day/Month 1979-cont.
SWITZERLAND	11	FAOCLIM. Version 2. World-wide agroclimatic data
SYRIA	29	FAOCLIM. Version 2. World-wide agroclimatic data
TAIWAN_PROVINCE_OF_C	107	FAOCLIM. Version 2. World-wide agroclimatic data
TAJIKISTAN	64	USSR. Data reference books on climate.
TUNISIA	35	FAOCLIM. Version 2. World-wide agroclimatic data
TURKEY	219	FAOCLIM. Version 2. World-wide agroclimatic data
TURKMENISTAN	75	FAOCLIM. Version 2. World-wide agroclimatic data
UAE	48	FAOCLIM. Version 2. World-wide agroclimatic data
UGANDA	9	FAOCLIM. Version 2. World-wide agroclimatic data
UKRAINE	39	FAOCLIM. Version 2. World-wide agroclimatic data
UNITED_KINGDOM	131	FAOCLIM. Version 2. World-wide agroclimatic data
UZBEKISTAN	65	FAOCLIM. Version 2. World-wide agroclimatic data
YEMEN	23	FAOCLIM. Version 2. World-wide agroclimatic data

Table 6. Data sources for potential evapotranspiration

AFGHANISTAN	18	FAOCLIM. Version 2. World-wide agroclimatic data
ALGERIA	32	FAOCLIM. Version 2. World-wide agroclimatic data
ARMENIA	49	FAOCLIM. Version 2. World-wide agroclimatic data
AUSTRIA	12	FAOCLIM. Version 2. World-wide agroclimatic data
AZERBAJAN	50	FAOCLIM. Version 2. World-wide agroclimatic data
BAHRAIN	1	FAOCLIM. Version 2. World-wide agroclimatic data
BANGLADESH	17	FAOCLIM. Version 2. World-wide agroclimatic data
BELARUS	3	FAOCLIM. Version 2. World-wide agroclimatic data
BELGIUM	2	FAOCLIM. Version 2. World-wide agroclimatic data
BOSNIA/HERZEGOVINA	3	FAOCLIM. Version 2. World-wide agroclimatic data
BULGARIA	9	FAOCLIM. Version 2. World-wide agroclimatic data
CENTRAL_AFRICAN_REP.	1	FAOCLIM. Version 2. World-wide agroclimatic data
CHAD	1	FAOCLIM. Version 2. World-wide agroclimatic data
CHINA	355	FAOCLIM. Version 2. World-wide agroclimatic data
CROATIA	10	FAOCLIM. Version 2. World-wide agroclimatic data
CYPRUS	25	FAOCLIM. Version 2. World-wide agroclimatic data
CZECHIA	5	FAOCLIM. Version 2. World-wide agroclimatic data
DENMARK	11	FAOCLIM. Version 2. World-wide agroclimatic data
DJIBOUTI	1	FAOCLIM. Version 2. World-wide agroclimatic data
EGYPT	33	FAOCLIM. Version 2. World-wide agroclimatic data
ERITREA	11	FAOCLIM. Version 2. World-wide agroclimatic data
ESTONIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
ETHIOPIA	70	FAOCLIM. Version 2. World-wide agroclimatic data
FINLAND	17	FAOCLIM. Version 2. World-wide agroclimatic data
FRANCE	77	FAOCLIM. Version 2. World-wide agroclimatic data
GEORGIA	88	FAOCLIM. Version 2. World-wide agroclimatic data
GERMANY_FED.REP.	75	FAOCLIM. Version 2. World-wide agroclimatic data
GREECE	22	FAOCLIM. Version 2. World-wide agroclimatic data
HUNGARY	6	FAOCLIM. Version 2. World-wide agroclimatic data
INDIA	206	FAOCLIM. Version 2. World-wide agroclimatic data
IRAN	279	FAOCLIM. Version 2. World-wide agroclimatic data
IRAQ	20	FAOCLIM. Version 2. World-wide agroclimatic data
IRELAND	17	FAOCLIM. Version 2. World-wide agroclimatic data
ISRAEL	7	FAOCLIM. Version 2. World-wide agroclimatic data
ITALY	80	FAOCLIM. Version 2. World-wide agroclimatic data
JAPAN	124	FAOCLIM. Version 2. World-wide agroclimatic data
JORDAN	29	FAOCLIM. Version 2. World-wide agroclimatic data
KAZAKHSTAN	123	FAOCLIM. Version 2. World-wide agroclimatic data
KENYA	4	FAOCLIM. Version 2. World-wide agroclimatic data
NORTH KOREA	5	FAOCLIM. Version 2. World-wide agroclimatic data
SOUTH KOREA	62	FAOCLIM. Version 2. World-wide agroclimatic data
KYRGYZSTAN	66	FAOCLIM. Version 2. World-wide agroclimatic data
LATVIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
LEBANON	12	FAOCLIM. Version 2. World-wide agroclimatic data
LIBYA	22	FAOCLIM. Version 2. World-wide agroclimatic data
LITHUANIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
MACEDONIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
MALI	6	FAOCLIM. Version 2. World-wide agroclimatic data
MAURITANIA	14	FAOCLIM. Version 2. World-wide agroclimatic data
MONGOLIA	19	FAOCLIM. Version 2. World-wide agroclimatic data
MOROCCO	20	FAOCLIM. Version 2. World-wide agroclimatic data
MYANMAR	28	FAOCLIM. Version 2. World-wide agroclimatic data

NEPAL	31	FAOCLIM. Version 2. World-wide agroclimatic data
NETHERLANDS	6	FAOCLIM. Version 2. World-wide agroclimatic data
NIGER	2	FAOCLIM. Version 2. World-wide agroclimatic data
NORWAY	12	FAOCLIM. Version 2. World-wide agroclimatic data
OMAN	6	FAOCLIM. Version 2. World-wide agroclimatic data
PAKISTAN	32	FAOCLIM. Version 2. World-wide agroclimatic data
POLAND	24	FAOCLIM. Version 2. World-wide agroclimatic data
PORTUGAL	18	FAOCLIM. Version 2. World-wide agroclimatic data
QATAR	1	FAOCLIM. Version 2. World-wide agroclimatic data
ROMANIA	14	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	238	FAOCLIM. Version 2. World-wide agroclimatic data
SAUDI ARABIA	23	FAOCLIM. Version 2. World-wide agroclimatic data
SENEGAL	3	FAOCLIM. Version 2. World-wide agroclimatic data
SERBIA&MONTENEGRO	5	FAOCLIM. Version 2. World-wide agroclimatic data
SLOVAKIA	4	FAOCLIM. Version 2. World-wide agroclimatic data
SLOVENIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
SOMALIA	19	FAOCLIM. Version 2. World-wide agroclimatic data
SPAIN	64	FAOCLIM. Version 2. World-wide agroclimatic data
SUDAN	63	FAOCLIM. Version 2. World-wide agroclimatic data
SWEDEN	17	FAOCLIM. Version 2. World-wide agroclimatic data
SWITZERLAND	9	FAOCLIM. Version 2. World-wide agroclimatic data
SYRIA	41	FAOCLIM. Version 2. World-wide agroclimatic data
TAIWAN_PROVINCE_OF_C	10	FAOCLIM. Version 2. World-wide agroclimatic data
TAJIKISTAN	59	FAOCLIM. Version 2. World-wide agroclimatic data
TUNISIA	16	FAOCLIM. Version 2. World-wide agroclimatic data
TURKEY	212	FAOCLIM. Version 2. World-wide agroclimatic data
TURKMENISTAN	62	FAOCLIM. Version 2. World-wide agroclimatic data
UAE	15	FAOCLIM. Version 2. World-wide agroclimatic data
UGANDA	1	FAOCLIM. Version 2. World-wide agroclimatic data
UKRAINE	14	FAOCLIM. Version 2. World-wide agroclimatic data
UNITED_KINGDOM	84	FAOCLIM. Version 2. World-wide agroclimatic data
UZBEKISTAN	50	FAOCLIM. Version 2. World-wide agroclimatic data
WESTERN_SAHARA	2	FAOCLIM. Version 2. World-wide agroclimatic data
YEMEN	13	FAOCLIM. Version 2. World-wide agroclimatic data

Table 7. Data sources for maximum temperature

COUNTRY	Number	Source Data
AFGHANISTAN	18	FAOCLIM. Version 2. World-wide agroclimatic data
ALGERIA	32	FAOCLIM. Version 2. World-wide agroclimatic data
ARMENIA	50	USSR. Data reference books on climate.
AUSTRIA	63	CAC Global CEAS Summary of Day/Month 1979-cont.
AUSTRIA	1	FAOCLIM. Version 2. World-wide agroclimatic data
AZERBAJAN	50	USSR. Data reference books on climate.
BAHRAIN	1	FAOCLIM. Version 2. World-wide agroclimatic data
BANGLADESH	21	FAOCLIM. Version 2. World-wide agroclimatic data
BELARUS	3	FAOCLIM. Version 2. World-wide agroclimatic data
BELGIUM	20	CAC Global CEAS Summary of Day/Month 1979-cont.
BOSNIA/HERZEGOVINA	3	FAOCLIM. Version 2. World-wide agroclimatic data
BULGARIA	34	CAC Global CEAS Summary of Day/Month 1979-cont.
CENTRAL_AFRICAN_REP.	1	FAOCLIM. Version 2. World-wide agroclimatic data
CHAD	2	FAOCLIM. Version 2. World-wide agroclimatic data
CHINA	1	CAC Global CEAS Summary of Day/Month 1979-cont.
CHINA	393	FAOCLIM. Version 2. World-wide agroclimatic data
CROATIA	10	FAOCLIM. Version 2. World-wide agroclimatic data
CYPRUS	28	FAOCLIM. Version 2. World-wide agroclimatic data
CZECHIA	5	CAC Global CEAS Summary of Day/Month 1979-cont.
DEM.REP.OF_CONGO	2	FAOCLIM. Version 2. World-wide agroclimatic data
DENMARK	29	CAC Global CEAS Summary of Day/Month 1979-cont.
DENMARK	7	FAOCLIM. Version 2. World-wide agroclimatic data
DJIBOUTI	1	FAOCLIM. Version 2. World-wide agroclimatic data
EGYPT	33	FAOCLIM. Version 2. World-wide agroclimatic data
ERITREA	11	FAOCLIM. Version 2. World-wide agroclimatic data
ESTONIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
ETHIOPIA	115	FAOCLIM. Version 2. World-wide agroclimatic data
FINLAND	49	CAC Global CEAS Summary of Day/Month 1979-cont.
FRANCE	81	FAOCLIM. Version 2. World-wide agroclimatic data
GEORGIA	90	USSR. Data reference books on climate.
GERMANY_FED.REP.	81	FAOCLIM. Version 2. World-wide agroclimatic data
GREECE	22	FAOCLIM. Version 2. World-wide agroclimatic data
HUNGARY	21	CAC Global CEAS Summary of Day/Month 1979-cont.
INDIA	230	FAOCLIM. Version 2. World-wide agroclimatic data
IRAN	548	Iran_MetDept_Climat
IRAQ	20	FAOCLIM. Version 2. World-wide agroclimatic data
IRELAND	18	FAOCLIM. Version 2. World-wide agroclimatic data
ISRAEL	7	FAOCLIM. Version 2. World-wide agroclimatic data
ITALY	91	FAOCLIM. Version 2. World-wide agroclimatic data
JAPAN	142	FAOCLIM. Version 2. World-wide agroclimatic data
JORDAN	29	FAOCLIM. Version 2. World-wide agroclimatic data
KAZAKHSTAN	123	USSR. Data reference books on climate.
KENYA	6	FAOCLIM. Version 2. World-wide agroclimatic data
NORTH KOREA	10	FAOCLIM. Version 2. World-wide agroclimatic data
SOUTH KOREA	71	FAOCLIM. Version 2. World-wide agroclimatic data
KYRGYZSTAN	72	USSR. Data reference books on climate.
LATVIA	7	CAC Global CEAS Summary of Day/Month 1979-cont.
LATVIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
LEBANON	15	USSR. Data reference books on climate.
LIBYA	24	FAOCLIM. Version 2. World-wide agroclimatic data
LIECHTENSTEIN	1	CAC Global CEAS Summary of Day/Month 1979-cont.

LITHUANIA	3	CAC Global CEAS Summary of Day/Month 1979-cont.
LITHUANIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
MACEDONIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
MALI	6	FAOCLIM. Version 2. World-wide agroclimatic data
MAURITANIA	14	FAOCLIM. Version 2. World-wide agroclimatic data
MONGOLIA	19	FAOCLIM. Version 2. World-wide agroclimatic data
MOROCCO	20	FAOCLIM. Version 2. World-wide agroclimatic data
MYANMAR	41	FAOCLIM. Version 2. World-wide agroclimatic data
NEPAL	35	FAOCLIM. Version 2. World-wide agroclimatic data
NETHERLANDS	18	CAC Global CEAS Summary of Day/Month 1979-cont.
NETHERLANDS	6	FAOCLIM. Version 2. World-wide agroclimatic data
NIGER	2	FAOCLIM. Version 2. World-wide agroclimatic data
NORWAY	99	CAC Global CEAS Summary of Day/Month 1979-cont.
OMAN	6	FAOCLIM. Version 2. World-wide agroclimatic data
PAKISTAN	32	FAOCLIM. Version 2. World-wide agroclimatic data
POLAND	27	FAOCLIM. Version 2. World-wide agroclimatic data
PORTUGAL	18	FAOCLIM. Version 2. World-wide agroclimatic data
QATAR	1	FAOCLIM. Version 2. World-wide agroclimatic data
ROMANIA	55	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	121	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	131	LAND RESOURCES OF RUSSIA CD-ROM
SAUDI ARABIA	23	FAOCLIM. Version 2. World-wide agroclimatic data
SENEGAL	3	FAOCLIM. Version 2. World-wide agroclimatic data
SERBIA&MONTENEGRO	5	FAOCLIM. Version 2. World-wide agroclimatic data
SLOVAKIA	4	CAC Global CEAS Summary of Day/Month 1979-cont.
SLOVENIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
SOMALIA	26	FAOCLIM. Version 2. World-wide agroclimatic data
SPAIN	65	FAOCLIM. Version 2. World-wide agroclimatic data
SUDAN	66	FAOCLIM. Version 2. World-wide agroclimatic data
SWEDEN	13	CAC Global CEAS Summary of Day/Month 1979-cont.
SWEDEN	89	CAC Global CEAS Summary of Day/Month 1979-cont.
SWITZERLAND	30	CAC Global CEAS Summary of Day/Month 1979-cont.
SWITZERLAND	3	FAOCLIM. Version 2. World-wide agroclimatic data
SYRIA	45	FAOCLIM. Version 2. World-wide agroclimatic data
TAIWAN_PROVINCE_OF_C	33	CAC Global CEAS Summary of Day/Month 1979-cont.
TAIWAN_PROVINCE_OF_C	9	FAOCLIM. Version 2. World-wide agroclimatic data
TAJIKISTAN	63	USSR. Data reference books on climate.
TUNISIA	20	FAOCLIM. Version 2. World-wide agroclimatic data
TURKEY	215	FAOCLIM. Version 2. World-wide agroclimatic data
TURKMENISTAN	71	FAOCLIM. Version 2. World-wide agroclimatic data
UAE	15	FAOCLIM. Version 2. World-wide agroclimatic data
UGANDA	2	FAOCLIM. Version 2. World-wide agroclimatic data
UKRAINE	14	FAOCLIM. Version 2. World-wide agroclimatic data
UNITED_KINGDOM	90	FAOCLIM. Version 2. World-wide agroclimatic data
UZBEKISTAN	50	FAOCLIM. Version 2. World-wide agroclimatic data
WESTERN_SAHARA	2	FAOCLIM. Version 2. World-wide agroclimatic data
YEMEN	13	FAOCLIM. Version 2. World-wide agroclimatic data

Table 8. Data sources for minimum temperature

COUNTRY	Number	Source Data
AFGHANISTAN	19	FAOCLIM. Version 2. World-wide agroclimatic data
ALGERIA	32	FAOCLIM. Version 2. World-wide agroclimatic data
ARMENIA	49	USSR. Data reference books on climate.
AUSTRIA	64	CAC Global CEAS Summary of Day/Month 1979-cont.
AUSTRIA	1	FAOCLIM. Version 2. World-wide agroclimatic data
AZERBAJAN	50	USSR. Data reference books on climate.
BAHRAIN	1	FAOCLIM. Version 2. World-wide agroclimatic data
BANGLADESH	21	FAOCLIM. Version 2. World-wide agroclimatic data
BELARUS	3	FAOCLIM. Version 2. World-wide agroclimatic data
BELGIUM	20	CAC Global CEAS Summary of Day/Month 1979-cont.
BOSNIA/HERZEGOVINA	3	FAOCLIM. Version 2. World-wide agroclimatic data
BULGARIA	33	CAC Global CEAS Summary of Day/Month 1979-cont.
CENTRAL_AFRICAN_REP.	1	FAOCLIM. Version 2. World-wide agroclimatic data
CHAD	2	FAOCLIM. Version 2. World-wide agroclimatic data
CHINA	1	CAC Global CEAS Summary of Day/Month 1979-cont.
CHINA	393	FAOCLIM. Version 2. World-wide agroclimatic data
CROATIA	10	FAOCLIM. Version 2. World-wide agroclimatic data
CYPRUS	28	FAOCLIM. Version 2. World-wide agroclimatic data
CZECHIA	5	CAC Global CEAS Summary of Day/Month 1979-cont.
DEM.REP.OF_CONGO	2	FAOCLIM. Version 2. World-wide agroclimatic data
DENMARK	28	CAC Global CEAS Summary of Day/Month 1979-cont.
DENMARK	1	FAOCLIM. Version 2. World-wide agroclimatic data
DENMARK	7	FAOCLIM. Version 2. World-wide agroclimatic data
DJIBOUTI	1	FAOCLIM. Version 2. World-wide agroclimatic data
EGYPT	33	FAOCLIM. Version 2. World-wide agroclimatic data
ERITREA	11	FAOCLIM. Version 2. World-wide agroclimatic data
ESTONIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
ETHIOPIA	113	FAOCLIM. Version 2. World-wide agroclimatic data
FINLAND	49	CAC Global CEAS Summary of Day/Month 1979-cont.
FRANCE	81	FAOCLIM. Version 2. World-wide agroclimatic data
GEORGIA	89	USSR. Data reference books on climate.
GERMANY_FED.REP.	81	FAOCLIM. Version 2. World-wide agroclimatic data
GREECE	22	FAOCLIM. Version 2. World-wide agroclimatic data
HUNGARY	21	CAC Global CEAS Summary of Day/Month 1979-cont.
INDIA	230	FAOCLIM. Version 2. World-wide agroclimatic data
IRAN	548	Iran_MetDept_Climat
IRAQ	20	FAOCLIM. Version 2. World-wide agroclimatic data
IRELAND	18	FAOCLIM. Version 2. World-wide agroclimatic data
ISRAEL	7	FAOCLIM. Version 2. World-wide agroclimatic data
ITALY	91	FAOCLIM. Version 2. World-wide agroclimatic data
JAPAN	142	FAOCLIM. Version 2. World-wide agroclimatic data
JORDAN	29	FAOCLIM. Version 2. World-wide agroclimatic data
KAZAKHSTAN	120	USSR. Data reference books on climate.
KENYA	6	FAOCLIM. Version 2. World-wide agroclimatic data
NORTH KOREA	10	FAOCLIM. Version 2. World-wide agroclimatic data
SOUTH KOREA	71	FAOCLIM. Version 2. World-wide agroclimatic data
KYRGYZSTAN	72	USSR. Data reference books on climate.
LATVIA	7	CAC Global CEAS Summary of Day/Month 1979-cont.
LATVIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
LEBANON	15	USSR. Data reference books on climate.
LIBYA	24	FAOCLIM. Version 2. World-wide agroclimatic data

LIECHTENSTEIN	1	CAC Global CEAS Summary of Day/Month 1979-cont.
LITHUANIA	2	CAC Global CEAS Summary of Day/Month 1979-cont.
LITHUANIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
MACEDONIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
MALI	6	FAOCLIM. Version 2. World-wide agroclimatic data
MAURITANIA	14	FAOCLIM. Version 2. World-wide agroclimatic data
MONGOLIA	19	FAOCLIM. Version 2. World-wide agroclimatic data
MOROCCO	20	FAOCLIM. Version 2. World-wide agroclimatic data
MYANMAR	41	FAOCLIM. Version 2. World-wide agroclimatic data
NEPAL	35	FAOCLIM. Version 2. World-wide agroclimatic data
NETHERLANDS	18	CAC Global CEAS Summary of Day/Month 1979-cont.
NETHERLANDS	6	FAOCLIM. Version 2. World-wide agroclimatic data
NIGER	2	FAOCLIM. Version 2. World-wide agroclimatic data
NORWAY	98	CAC Global CEAS Summary of Day/Month 1979-cont.
OMAN	6	FAOCLIM. Version 2. World-wide agroclimatic data
PAKISTAN	32	FAOCLIM. Version 2. World-wide agroclimatic data
POLAND	27	FAOCLIM. Version 2. World-wide agroclimatic data
PORTUGAL	18	FAOCLIM. Version 2. World-wide agroclimatic data
QATAR	1	FAOCLIM. Version 2. World-wide agroclimatic data
ROMANIA	55	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	121	FAOCLIM. Version 2. World-wide agroclimatic data
RUSSIAN_FEDERATION	132	LAND RESOURCES OF RUSSIA CD-ROM
SAUDI ARABIA	23	FAOCLIM. Version 2. World-wide agroclimatic data
SENEGAL	3	FAOCLIM. Version 2. World-wide agroclimatic data
SERBIA&MONTENEGRO	5	FAOCLIM. Version 2. World-wide agroclimatic data
SLOVAKIA	4	CAC Global CEAS Summary of Day/Month 1979-cont.
SLOVENIA	2	FAOCLIM. Version 2. World-wide agroclimatic data
SOMALIA	26	FAOCLIM. Version 2. World-wide agroclimatic data
SPAIN	65	FAOCLIM. Version 2. World-wide agroclimatic data
SUDAN	66	FAOCLIM. Version 2. World-wide agroclimatic data
SWEDEN	101	CAC Global CEAS Summary of Day/Month 1979-cont.
SWITZERLAND	30	CAC Global CEAS Summary of Day/Month 1979-cont.
SWITZERLAND	3	FAOCLIM. Version 2. World-wide agroclimatic data
SYRIA	45	FAOCLIM. Version 2. World-wide agroclimatic data
TAIWAN_PROVINCE_OF_C	33	CAC Global CEAS Summary of Day/Month 1979-cont.
TAIWAN_PROVINCE_OF_C	8	FAOCLIM. Version 2. World-wide agroclimatic data
TAJIKISTAN	60	USSR. Data reference books on climate.
TUNISIA	20	FAOCLIM. Version 2. World-wide agroclimatic data
TURKEY	215	FAOCLIM. Version 2. World-wide agroclimatic data
TURKMENISTAN	71	USSR. Data reference books on climate.
UAE	15	FAOCLIM. Version 2. World-wide agroclimatic data
UGANDA	2	FAOCLIM. Version 2. World-wide agroclimatic data
UKRAINE	14	FAOCLIM. Version 2. World-wide agroclimatic data
UNITED_KINGDOM	89	FAOCLIM. Version 2. World-wide agroclimatic data
UZBEKISTAN	50	USSR. Data reference books on climate.
WESTERN_SAHARA	2	FAOCLIM. Version 2. World-wide agroclimatic data
YEMEN	13	FAOCLIM. Version 2. World-wide agroclimatic data