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Soil and Agriclimatic Information Contained in Polish Contemporary Atlases and Its Usability for Agricultural Purposes

1. Introduction

The sustainable development of agricultural land has to be based on a good knowledge of natural conditions and undergoing changes on the environment. Polish agriculture faces problems how to provide food to a nation of about 40 million people and how to compete with other European farmers. The productivity increase requires profound knowledge especially within the scope of soil and climatic parameters conditioning land productivity, capability for plant cultivating, farmland valuation, etc. The soil-climatic conditions influence in more than 50% yields of agricultural plants.

The physiographic information may be obtained, besides direct measurements, methods of photogrammetry and remote sensing, also by the use of existing maps and documentation attached to them [10, 12]. Especially the images acquired by NOAA satellites are being used to recognize the state of vegetation growth, to detect and monitor of drought, etc. [8]. From the point of view of agricultural development the most popular numerical data used in practice (from databases and information systems) comprise soils, areas protected, contaminated, threatened by droughts or floods and climate [11, 13, 14].

The majority of sources of information about natural conditions are widespread and do not comprise all territory of the country, hence the role of national and regional atlases seems to be of special significance. Many atlases completed lately in Poland may provide valuable information concerning soil and climatic parameters.

The general aim of the paper is to present the elements important from the viewpoint of agriculture concerning soil and agriclimatic conditions (general conditions, threat to agriculture, risk of yields, etc.) and their cartographic presentation in the atlases.

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In conclusion the ranking of data of intrinsic importance for agriculture and land estate valuation contained in the thematic maps of analyzed atlases has also been done.

2. General Presentation of Atlases

The general concept of the *Atlas of the Republic of Poland* (AR) came into being at the Institute of Geography and Spatial Organization of the Polish Academy of Science. The editing and permanent updating of the atlas, instead publishing successive new editions is being done since 1993.

The concept of the scope of the contents, graphic solutions and editing from of the AR is-to the largest possible extent-compliant with the needs and demands of its prospective users. The atlas contains over 900 maps and 200 diagrams in four thematic parts: I – Country, territory, organization, II – Natural environment, III – Society, IV – Economy.

Part II consists of maps informing about the geological structure, relief, waters, climate, vegetation and fauna, as well as transformations and protection of the natural environment.

The basic maps in the atlas are these at the scale of 1: 1,500,000. This format is the maximum size of an atlas map which already makes it possible to provide a considerably detailed presentation of particular phenomena at the scale of the entire country. The atlas also contains numerous maps at derivative scales 1: 3,000,000, 1: 4,500,000 and 1: 6,000,000 and other scales [6].

Each part of the AR is preceded by an introduction which presents its contents in brief.

At the back side of each map sheet there is a list of thematic maps it includes and the index of source material and short methodological comment.

Most maps have been prepared using MS Excel, MapInfo, Arc/Info, Corel/Chart Software, Adobe Illustrator software and drawn in Corel/Draw and Macromedia FreeHand. The thematic maps concerning soils and climate are presented by the use of isorythmic method (isolines) and colours.

The preparation of the *Atlas of Soil Moisture under Field Crops in Poland* (ASM) worked up in the University of Agriculture in Szczecin is based on multi-year meteorological data and the measurements of soil moisture from agrometeorological stations [7]. The cartographic information contained in the ASM is a practical guide for farmers and institutions involved in soil development.

The atlas contains 210 maps (mainly at the scales 1: 6,000,000 and 1: 8,000,000) and 230 diagrams. The ASM comprises detailed information on temporal and spa-

tial distribution of topsoil moisture within provinces and the whole country. The essential method of water conditions presentation bases on the cartograms, isolines and colours.

The *Atlas of Geographical Environment of Poland* (AGE) has been created in the Institute of Geography and Spatial Organization of the Polish Academy of Sciences and presents an integrated, synthetic approach to the basic problems of the country's nature conservation. It contains rich information concerning quantity and quality, natural features of the environment, its resources and the scope and directions of its change [5].

The atlas should be treated as a cartographic documentation of the state of protection of Poland's natural environment and threat looming over it.

The atlas contains 97 multicoloured tables with 444 maps, charts and diagrams. The basic scales of the maps are: 1: 4,000,000, 1: 6,000,000 and 1: 8,000,000.

The maps are grouped in 11 thematic sections, among them: Climatic phenomena (section II) and *Soil valuation and utilization* (section VI). The maps concerning climate and soils are presented by the use of isolines and colours.

The *Atlas of Climatic Risk to Crop Cultivation in Poland* (ACR) worked up in the University of Agriculture in Szczecin is based on the data collected for many years by the Institute of Meteorology and Water Management, various experimental stations, research and statistical offices [3].

The authors have created a compact and extensive presentation of climatic conditions (isolines, cartograms), connected with agricultural production in our country. The basic scales of the maps are: 1:6,000,000 and 1: 8,000,000.

The *Atlas of Climate of Poland* (AC), worked up by the Institute of Meteorology and Water Management, contains 157 climatic maps in the scales of: 1: 5,000,000 and 1: 8,000,000, based on the data from 90 meteorological stations collected in the years 1971–2000 [2]. Maps drawn in the first phase using traditional method, in the second phase have been transferred to the atlas using computer programme COREL.

The basic methods of maps content presentation are isolines and colours. The thematic range of the AC comprises such elements as: winds, air temperatures, air humidity, precipitation, snow cover, atmospheric phenomena, etc.

The *Internet Atlas of Poland* (IA) is available under http address since spring 2006 [9]. The atlas is a public, free cartographic resource with over 100 socio-economic and environmental maps as well as the Topographic Map of Poland with variable scale up to 1: 100,000 and the Gazetteer with 44,000 settlement names. A software engine for the whole project, developed in the Institute of Geography and Spatial Organization, Polish Academy of Sciences is AIMS (Aviso Internet Map Server). AIMS is an extension module featuring GIS vector map processing

and raster map output. The IA contains, among others, 32 climatic maps in the scales from 1: 6,000,000 to 1: 3,000,000 – presenting their contents by the use of isolines and colours.

The *Atlas the Climate of the Silesian Province* (ACS). The atlas worked up in the Institute of Meteorology and Water Management in Poland is based on the data comprising period from 1966–1995 [4]. The data present climatic characteristics mainly for months: January, April, July, October. The majority of maps are completed at the scale of 1: 700,000 and bases on the isorythmic or cartodiagram method.

The entrance data coming from the meteorological stations prepared in the form of text, next have been interpolated by the use of computer program SURFER – obtaining maps with thus isolines and colours. The climatic phenomena are presented on the background of relief, generalized water network and settlements. The thematic range of maps contained in the ACS comprise such climatic problems, as: sunshine and cloudiness, air temperature, precipitation, wind, air humidity, atmospheric phenomena, etc.

The Atlas of the Climate of the Great Poland Province (ACG) worked up in the Institute of Meteorology and Water Management in Katowice is based on the meteorological data comprising period from the year 1971 to 2000 [1].

Most maps are completed at the scales 1: 1,300,000 and 1: 2,700,000 and bases on the isorythmic or cartodiagram methods. The data coming from meteorological stations completed in GIS, next have been interpolated by the use of Arc GIS programme. The climatic phenomena are presented on the background of relief, water network and settlements. The thematic range of maps contained in the ACG is in general similar to this in the ACS.

3. Soil and Agriclimatic Information Contained in the Atlases

The *Atlas of the Republic of Poland* (AR) shows differentiation of soils in genetic and qualitative aspect, as well as physical and chemical properties of soils significant for proper utilization, e.g: 1. Granularity (1: 1,500,000), 2. Water conditions (1: 3,000,000), 3. Soil reaction (1: 3,000,000), 4. Occurrence of calcium carbonate (1: 3,000,000), 5. Soil – qualitative classification (1: 1,500,000).

The climatic maps contained in the AR show the probability of occurrence of a definite intensity of the presented phenomenon (element) or they present a new synthesis of the climate of Poland, at the scales of 1: 6,000,000 and 1: 8,000,000, e.g.: 1. Mean duration of thermic summer (mean daily temperature above 15°C), 2. Mean duration of thermic winter (mean daily temperature below 0°C), 3. Dates

of first autumn freeze of 0°C (probability 10%, 50%, 90%), 4. Duration of the freeze-free period (probability 10%, 50%, 90%), 5. Annual number of days with snow cover (probability 10%, 50%, 90%), 6. Spring (III–V) precipitation (probability 10%, 50%, 90%), 7. Summer (VI – VIII) precipitation (probability 10%, 50%, 90%), 8. Autumn (IX–XI) precipitation (probability 10%, 50%, 90%), 9. Annual precipitation (probability 10%, 50%, 90%).

The *Atlas of Soil Moisture under Field Crops* (ASM) presents temporal and spatial distribution of numerous indices characterizing moisture conditions of topsoil in 10-day periods, months, three periods (1 IV – 30 VI, 1 VII – 10 IX and 11 IX – 31 X) and the whole growing season (1 IV – 31 X), years. The analysis focuses on three types of moisture (excessive, sufficient and insufficient), the areas of diversified topsoil moisture and the zones of potential threat to crops caused by extreme soil moisture during the growing season.

The thematic maps (1: 6,000,000 or 1: 8,000,000) contained in the ASM comprise such information, as: 1. Excessive soil moisture (spatial distribution, seasons frequency), 2. Mean duration of periods with excessive soil moisture, 3. Sufficient soil moisture (spatial distribution, seasons, frequency), 4. Mean length of periods with sufficient soil moisture, 5. Insufficient soil moisture (spatial distribution, seasons, frequency), 6. Mean duration of periods with insufficient soil moisture, 7. Excessive soil moisture index in vegetation period, 8. Insufficient soil moisture index in vegetation period, 9. Zones of potential threat to crops caused by extreme soil moisture.

The *Atlas of Geographical Environment of Poland* (AGE) presents numerous maps concerning soils and agriclimate of intrinsic value for rural land activity.

The soil maps concern, among others such problems, as: 1. Soil valuation, 1: 2,00,00 (six classes of soils), 2. Soils protected for agriculture, 1: 2,000,000 (four categories of land), 3. Chemicalization of agriculture, 1: 6,000,000 (consumption of: artificial fertilizers and plant pesticides per 100 ha agricultural land in kg), 4. Valorization (evaluation) of agricultural space, 1: 2,000,000 (agroecological conditions on a 100 – point scale).

In the range of agriclimate the thematic maps in the AGE concern such topics, as: 1. Climatic water balance, 1: 6,000,000 (precipitation, evaporation, water balance indices), 2. Thermal soil conditions, 1: 6,000,000 (dates of various threshold temperatures at a depth of 10 cm), 3. Climatic hazards to agriculture (%), 1: 6,000,000 (rainless periods, heavy rains, hail routes ground frosts and zones of potential hazard to crops), 4. Climatic valuation for agriculture, 1: 2000,000 (a 100 – point scale).

The Atlas of Climatic Risk for Crop Cultivation in Poland (ACR). The agriclimate maps (1: 8,000,000) presented in the atlas concern among others, such important for agriculture and farmland valuation problems, as: 1. Climatic water balance,

2. Winter losses in crops (%) – wheat, rye, triticale, barley, agrimony, red clover, 3. Excessive precipitation to crops (wheat, rape, barley, potatoe, sugar beet), 4. Insufficient precipitation to crops (wheat, barley, oats, maize, potato), 5. Extreme soil moisture – potential yield decrease (%) – risk to wheat, barley, rye, triticale, rape, oats, potatoe, sugar beet, 6. Threat to cultivated plants by spring ground frosts (small, medium, great, very great), 7. Hail losses in cereals and root crops (%), 8. Flood losses in cereals and root crops (%), 9. Zones of threat to field crops (%).

The *Atlas of Climate of Poland* (AC) concern such problems important for agriculture, as: 1. Number of days with ground frost ($T_{\min} < 0^{\circ}\text{C}$), 2. Number of very frosty days ($T_{\max} \leq -10^{\circ}\text{C}$), 3. Number of hot days ($T_{\min} \geq 30^{\circ}\text{C}$), 4. Annual mean precipitation totals, 5. Mean snow cover depth in season, 6. Annual mean number of days with hail.

The *Internet Atlas of Poland* (IA) contains also some maps at the scales of 1 : 3,000,000 and 1 : 6,000,000 interesting from the point of view of agriculture, containing, such climate data, as:

- frequency of chosen weather phenomena (storms, rains, snow cover);
- types of weather (number of days in the year), e.g.: warm, cloudy, with rainfall; warm, sunny, without rainfall; frosty, cloudy, with snowfall; frosty, sunny, without snowfall; with ground frost cloudy, without snowfall; with ground frost, sunny, without snowfall.

The *Atlas of Climate of the Silesian Province* (ACS) (1: 700,000) concern such problems, important for farming, agriculture development and land valuation, as: 1. Annual mean air temperature, 2. Monthly mean air temperature: I, IV, VII, X, 3. Mean number of days with frost in the period: I–X, 4. Mean dates of first autumn frosts, 5. Mean dates last spring frosts, 6. Mean dates of the beginning of the spring, summer, autumn, winter, 7. Monthly mean precipitation: I, IV, VII, X, 8. Annual mean number of days with snow cover, 9. Mean dates of appearing and vanishing of snow cover, 10. Monthly mean relative air humidity: I, IV, VII, X, 11. Annual mean number of days with hail.

The *Atlas of the Climate of the Great Poland Province* (ACG) (scales: 1: 1,300,000 and 1: 2,700,000) concern such problems important for farming, agriculture development and land valuation, as: 1. Annual mean air temperature, 2. Monthly mean air temperature: I, IV, VII, X, 3. Mean number of days with frost, 4. Mean number of days with frost in the period: IV–X, 5. Mean dates of last spring frosts, 6. Mean dates of first autumn frost, 7. Mean number of days of the vegetation period, 8. Monthly mean precipitation totals: I, IV, VII, X, 9. Mean precipitation totals in the vegetation period (IV – X), 10. Mean dates of appearing and vanishing of snow cover, 11. Annual mean number of days with snow cover, 12. Annual mean relative air humidity, 13. Annual mean number of days with hail.

4. Usability of Thematic Maps for Agriculture and Farmland Valuation

The author has chosen 72 maps from atlases – belonging to two thematic groups – soils (S): AR – S:5, ASM – S:9, AGE – S:4 and agriclimatic conditions (C): AR – C:9, AGE – C:4, ACR – C:9, AC – C:6, IA – C:2, ACS – C:11, ACG – C:13. The letter symbol denotes abbreviation of the atlas name and thematic group, the number denotes amount of maps. Thus, there are 18 maps concerning soils and 54 maps concerning climatic conditions.

Analyzing the usability of maps for agricultural purposes the author distinguished three directions of their use: farming (conditioning of cultivation, adequate choice of crops, needs for fertilization and irrigation, predicting the yields, etc.), agricultural development (planning, regionalization, land protection) and farmland valuation.

Two categories of the usability of these maps for the above mentioned purposes have been distinguished: moderate (M) and high (H). Moderate usability value of information means, that data presented in the map are of auxiliary meaning or are useful to some extent, and high usability – of intrinsic importance for a given problem.

Thematic maps concerning soils provide in 36 cases – moderate and in 18 cases high value information for various agricultural purposes. Similarly, thematic maps concerning agriclimate submit in 116 cases – moderate and in 47 cases high value information for various agricultural aims (Tab. 1).

Next, we will consider thematic maps of high information value (usability) for agriculture.

There are 9 **soil maps** of high usability for farming (farmland production) contained in the atlases: AR: Water conditions, Soil reaction, Soil qualitative classification; ASM: Excessive soil moisture, Sufficient soil moisture, Insufficient soil moisture, Zones of potential threat to crops caused by extreme soil moisture; AGE: Soil valuation, Valorization of agricultural space.

The above maps provide important general information for farming in the range of soil potential for agricultural production.

The following 6 **soil maps** are of intrinsic (high) information value for agriculture development: AR: Soil – qualitative classification; ASM: Zones of potential threat to crops caused by extreme soil moisture; AGE: Soil valuation, Soils protected for agriculture, Chemicalization of agriculture, Valorization of agricultural space. These thematic maps provide important information for agricultural land development e.g. planning, management, regionalization of crops, farmland protection in the investment processes a.s.o.

Table 1. Usability of maps for agricultural purposes

Symbol of the Atlas	Thematic group: S – soils C – agriclimate	Number of map	Usefulness for		
			farming	agricultural development	farmland valuation
AR	S	1	M	M	M
		2	H	M	M
		3	H	M	M
		4	M	M	M
		5	H	H	H
ASM	S	1	H	M	M
		2	M	M	M
		3	H	M	M
		4	M	M	M
		5	H	M	M
		6	M	M	M
		7	M	M	M
		8	M	M	M
		9	H	H	H
AGE	S	1	H	H	H
		2	M	H	M
		3	M	H	M
		4	H	H	M
AR	C	1	M	M	M
		2	M	M	M
		3	M	M	M
		4	M	M	M
		5	M	M	M
		6	M	M	M
		7	M	M	M
		8	M	M	M
		9	M	M	M
AGE	C	1	M	H	M
		2	M	M	M
		3	H	H	H
		4	H	H	H
ACR	C	1	M	M	M
		2	H	M	H
		3	H	M	M
		4	H	M	H
		5	H	M	M
		6	H	M	H
		7	H	H	H
		8	H	H	H
		9	H	H	H
AC	C	1	M	M	M
		2	M	M	M
		3	M	M	M
		4	M	M	M
		5	M	M	M
		6	H	H	H
IA	C	1	M	M	M
		2	M	M	M

Table 1 cont.

ACS	C	1	M	M	M
		2	M	M	M
		3	M	M	M
		4	H	M	M
		5	H	M	M
		6	H	M	M
		7	H	M	M
		8	M	M	M
		9	H	M	M
		10	M	M	M
		11	H	H	H
ACG	C	1	M	M	M
		2	M	M	M
		3	M	M	M
		4	H	M	M
		5	H	M	M
		6	H	M	M
		7	H	H	H
		8	H	M	M
		9	H	M	M
		10	H	M	M
		11	M	M	M
		12	M	M	M
		13	H	H	H

The following 3 maps concerning **soils** are of high usability for agricultural land valuation: AR: Soil quantitative classification; ASM: Zones of potential threat to crops caused by extreme soil moisture; AGE: Soil valuation.

The above maps provide import general information useful in application of various approaches to farmland valuation.

There are 25 **climatic maps** of high usefulness for farming (farmland production): AGE: Climatic hazards to agriculture (%), Climatic valuation for agriculture; ACR: Winter losses in crops; Excessive precipitation to crops, Insufficient precipitation to crops, Extreme soil moisture, Threat to cultivated plants by spring ground frosts, Hail losses, Flood losses in cereals and root crops, Zones of threat to field crops; AC: Annual number of days with hail; ACS: Mean dates of first autumn frosts, Mean dates of last spring frosts, Mean dates of the beginning of: spring, summer, autumn, winter, Monthly mean precipitation, Mean dates of appearing and vanishing of snow cover, Annual mean number of days with hail; ACG: Mean number of days with frost in the period: IV–X, Mean dates of last spring frosts, Mean dates of first autumn frosts, Mean number of days of the vegetation period, Monthly mean precipitation totals: I, IV, VII, X, Mean precipitation totals in the vegetation period (IV–X), Mean dates of appearing and vanishing of snow cover, Annual number of days with hail.

The following 10 thematic maps concerning **agroclimatic conditions** are of intrinsic (high) significance for agricultural development: AGE: Climatic water

balance, Climatic hazards to agriculture, Climatic valuation for agriculture; ACR: Hail losses in cereals and root crops, Flood losses in cereals and root crops, Zones of threat to field crops; AC: Annual mean number of days with hail; ACS: Annual mean number of days with hail; ACG: Mean number of days of the vegetation period, Annual mean number of days with hail.

The following 12 **agroclimatic maps** are of high importance for farmland valuation, especially by the use of mixed approach method based on estimative indices (see: [16]): AGE: Climatic hazards to agriculture, Climatic valuation for agriculture; ACR: Winter losses in crops, Insufficient precipitation to crops, Threat to cultivated plants by spring ground frosts, Hail losses in cereals and root crops, Flood losses in cereals and crops, Zones of threat to field crops; AC: Annual mean number of days with hail; ACS: Annual mean number of days with hail; ACG Mean number of days of the vegetation period, Annual mean number of days with hail.

The ranking of atlases, taking into consideration maps of high informative value, have been presented below. The most useful for farming:

- in the range of **soil** data, are the following atlases: ASM – 5 thematic maps, AR and AGE – 2 thematic maps each;
- in the range of **agroclimatic** data, are the following atlases: ACR and ACG: – 8 thematic maps each, ACS – 6 thematic maps, AGE – 2 thematic maps, AC – 1 thematic map.

The highest usability for agricultural land is represented by the following atlases:

- in the range of **soil** information: AGE – 4 thematic maps, AR and ASM – 1 thematic map each;
- in the range of **agroclimatic** information: AGE and ACR – 3 thematic maps each, ACG – 2 thematic maps, AC and ACS – 1 thematic map each.

The highest usability for farmland (agricultural real estate) valuation is represented by atlases:

- in the range of **soil** information: AR, ASM and AGE – 1 thematic map each;
- in the range of **agroclimatic** data: ACR – 6 thematic maps, AGE and ACG – 2 thematic maps each, AC and ACS – 1 thematic map each.

5. Final Remarks

Eight atlases have been analyzed in the paper, including six atlases concerning the whole country (AR, ASM, AGE, ACR, AC, IA) and two regional atlases (ACS, ACG).

Most thematic maps concerning soil and agriclimatic data have been accomplished with the use of isorythms (isolines), cartograms, less of them using cartodiagrams.

The majority of map scales contained in the country atlases is within the range of scale from 1: 3,000,000 to 1: 8,000,000, whereas in regional atlases from 1: 700,000 to 1: 2,700,000.

Chosen thematic maps concerning soils provide in 18 cases high value information for various agricultural purposes, especially contained in the ASM, AGE and AR. Selected thematic maps concerning agriclimate submit in 47 cases high value information for various agricultural aims, especially contained in the ACR, ACG, ACS and AGE.

The information contained in the thematic maps of analyzed atlases create a comprehensive, spatially oriented documentation of the phenomena and processes over a certain time interval valuable, among others, from the viewpoint of farming, agricultural development and farmland valuation.

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