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Article

Spatial Multi-Criteria Analysis of Water-Covered Areas: District City of Katowice—Case Study

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Abstract: The following databases contains information on land use with water in Poland: Corine Land Cover (CLC), the Urban Atlas (UA); Database of Topographic Objects (BDOT) the digital Map of Poland's Hydrographic Division (MPHP); and the Register of Lands and Buildings (EGiB). All these data are referenced in scientific analyses and the Polish water management system, so the results of their processing should be the same (or at least similar); if not, output materials will be inconsistent and unreliable. In the Katowice sample, we checked the quality of this data using multi-criteria analyses, which is based on a grid of equal-area hexagons. Additionally, we applied the Normalized Difference Water Index to check real-time water presence. We detected discrepancies between all the data. The CLC does not reference any flowing water in Katowice. Most data overlapped between MPHP and BDOT, and both databases were similar to UA. However, a lot of uncertainty was also observed in the EGiB, which is considered to be the most accurate of the databases surveyed. In conclusion, we argue that water land cover data should be used with caution, and depending on the scales of analysis, that most actual data could be remote sensed data. We also include a diagram which can be useful in the data selection process.

Keywords: Katowice; surface water; remote sensing; GIS; hexagons; spatial databases; land cover; land use; retention

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1. Introduction

Surface water is one of the basic land cover classes in various databases. In contrast to many other types of land use (e.g., agricultural areas, forests), water is dynamic, and therefore in each update in land cover classification, its extent always differs from the original one [1]. The progress of erosion processes is particularly visible on a local scale, e.g., through changes in the shoreline formation of lakes, rivers and oxbow lakes. For this reason, precise mapping of areas actually covered with water is important due to its wide social, legal and economic impact [1]. Referring to the legal act regulating Polish water management, Art. 211 of the Water Law Act of 20 July 2017 [2], land covered with inland flowing waters cannot be subject to civil law transactions. As stipulated by the regulation of the Minister of Regional Development and Construction on the register of land and buildings [3], the land occupied by a natural watercourse constitutes a separate cadastral plot within the shoreline, regardless of whether the water flows in a natural or regulated and open or covered riverbed. According to the Act on real estate management, land covered with water is exclusively owned by the State [4]. The above-quoted regulations on the ownership of surface waters show the essence of the issues related to the proper indication of water-covered lands. The correct determination of the extent of water cover is also important for local spatial development (most often in communal areas) when preparing planning documents or making strategic (and all other) investment decisions in each field (water, water supply, road, oil, gas infrastructure, etc.) [5–7]. Analyses of land cover and land use by surface waters are also carried out in the field of agricultural water management [8]. For this reason, we tried to carry out multicriterial analyses on the discrepancies between the often-updated large-scale local database and other data sources in the field of land cover with a hydrographic network.

Proper spatial mapping of water coverage is important for scientific studies conducted in the global, regional and local scope, e.g., on improving the quality of surface waters, reducing the emission of harmful substances and pollutants, fluctuations in the water balance and climatic variability [9–13].

It is particularly hard to identify land covered by water in urban areas. This is related to, e.g., difficult remote detection due to high buildings and shadows, or when surface water flows in water devices (including covered infrastructure like pipes or under bridges) [14,15]. For this reason, the urbanized area of Katowice was chosen as the research area.

The research was based on a comparison of the existing land cover classifications. For the city of Katowice, the following databases contain vectorized layers on land use and land cover (including areas covered by water): Corine Land Cover 2018 (CLC 2018), Urban Atlas (UA), Database of Topographic Objects (pol. *Baza Danych Obiektów Topograficznych*—BDOT), Digital Map of Poland's Hydrographic Division (pol. *Mapa Podziału Hydrograficznego Polski*—MPHP), and the Register of Land and Buildings (pol. *Ewidencja Gruntów i Budynków*—EGiB).

Except for lakes and water reservoirs, the water coverage of the area should correspond to the areas where the rivers run. Therefore, the linear layers of the Database of Topographic Objects and the Map of the Hydrographic Division of Poland were used in the research.

Most LULC (land use/land cover) maps are based on imagery processing. Nowadays this involves high-resolution materials, computed automatically e.g., using deep learning algorithms [16]. However, remote detection of water-covered lands is possible based on medium-resolution remote-sensing imagery [17]. Satellite images can also be used for this purpose. One of many remote sensing methods is using water indicators, which are based on differences in spectral reflectance [18,19]. These are most widely used to assess the quality of surface waters and changes in the shorelines [20,21]. Obtaining LULC layers from Imagery is possible not only by remote sensing but also by geoprocessing tools [22]. Using multi-criterial analysis based on combined methods enhances the reliability of LULC classification [23].

Every surface is characterized by a specific range of absorbed and reflected radiation. Water areas have a completely different reflection than, for example, vegetated or sealed areas [24]. Because the satellite sensor registers the image in several spectral channels corresponding to a specific range of radiation reflected from the surface, it is possible to perform simple transformations of the pixel matrix, which makes it possible to isolate the desired areas, e.g., those covered with water [25]. We used the Normalized Difference Water Index—NDWI, developed and distributed by Bo-Cai Gao in 1996 [26]. This indicator is presented in two variants as the quotient of the sum and the difference of the near infrared and shortwave infrared ranges, or after modification for open waters by Stuart McFeeters as the quotient of the sum and the difference of the green and shortwave ranges [27]. The precision of determining areas covered with water using this indicator is limited by the errors of the detector or atmospheric correction and because of the radiometric and spatial resolution of satellite images. Publicly available satellite images of the Sentinel-2 mission with GSD = 10 m were used in the research. Due to the extensive use of land cover data, it is necessary to be sure of their correctness [28]. A method facilitating an objective comparison of data and detecting discrepancies in the spatial dimension is the multi-criteria spatial analysis presented in this article, based on Geographic Information Systems software algorithms.

2. Study Area

Katowice is a city with *powiat* rights in Poland and the capital of the Silesian Voivodeship. It is the main centre of the Metropolis GZM (pol. *Górnośląsko-Zagłębiowska Metropolia*) and the largest city in the Upper Silesian conurbation in terms of population. The population on 31.12.2022 was 269,367 people. The area of the city is 164.64 km^2.

According to the physical–geographic division [29], Katowice is largely located in the Katowice Upland mesoregion (341.13). This mesoregion is the southern part of the Silesian Upland, which is part of the Silesian-Cracow Upland subprovince. Geologically, the city is located in the Devonian-Carboniferous Upper Silesian sinkhole. The city lies on the border of the Vistula and the Oder watersheds. Katowice in the Vistula basin is drained by the rivers: Rawa, Brynica and Bolina, which are tributaries of the Przemsza river. The Kłodnica River, which originates in Katowice, with the Ślepiotka and smaller tributaries, discharges water into the Oder (Figure 1).

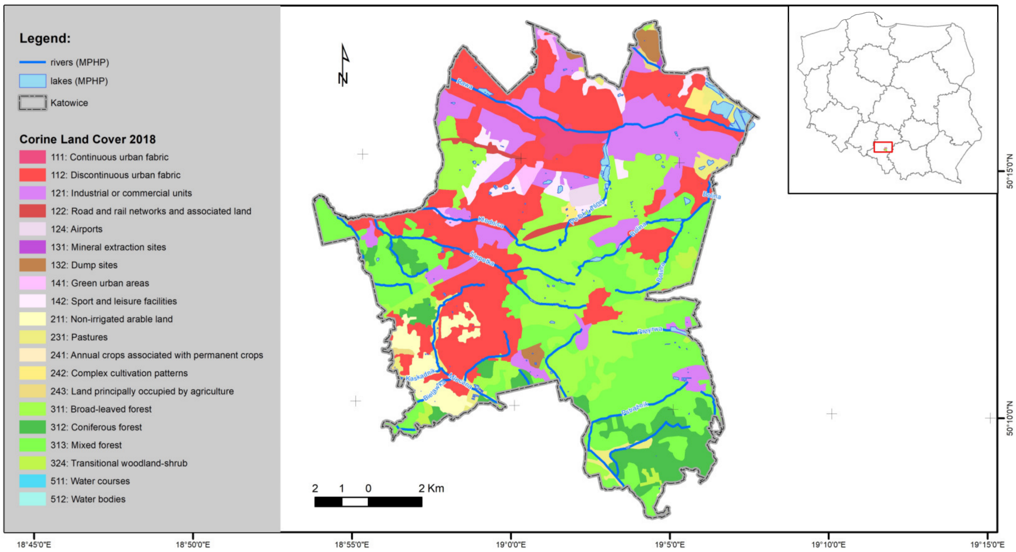

Figure 1. City of Katowice—land cover by Corine Land Cover and hydrographic network. Source: own study.

Katowice developed in an area where hard coal is found and exploited. The exploitation of coal, which has been taking place for over 200 years with varying intensity, has led to changes in the natural environment, mainly regarding relief and water relations [30]. The main effects of coal mining in Katowice are the deformation of the earth's surface, the creation of floodplains, damage to technical infrastructure, the formation of a depression cone, and pollution of surface waters with discharges of mine waters [31].

In Katowice, there are several dozen anthropogenic water reservoirs with a total area of 203 ha (not including unfixed floodplains in forest areas), of which 30 have an area exceeding 1 ha. They are an element of small water retention. Nearly half of the total area of water reservoirs can be found in the complex of ponds located at the border of Katowice, Sosnowiec and Mysłowice (89 ha in Katowice), created in former sand pits [32]. Reservoirs in subsidence basins and sinkholes are characterized by high dynamics referring to the occupied area and their number. Initially, periodic flooding turns into floodplains. They are particularly burdensome because they force a change in the use of neighboring areas, and as a consequence, they often force reclamation works [33]. The hydrography of Katowice according to the Map of the Hydrographic Division of Poland is presented in Figure 1. The names of ditches and "tributaries from . . . " are not indicated where there is no certainty as to their nature (Figure 1). These objects were therefore excluded from the following analysis.

Water reservoirs in Katowice are important objects of cultural and industrial heritage, which at the same time have great potential in mitigating the effects of climate change. The large number of water reservoirs in this area allows them to be used as recreational areas, attractive natural areas and important water resources for the region. The development of these reservoirs includes, among others, activities aimed at maintaining and/or restoring the principles of sustainable water management [34].

In light of the analyses of climate scenarios for Katowice, it appears that the main threats related to climate change include, among others: a greater number of hot days and heat waves; urban heat islands; short intense rainfall that may cause urban flooding; and long-term precipitation-free periods, which, combined with high air temperature, will cause more days with thunderstorms and bad weather conditions. Rational use of the existing water reservoirs in the cities of the GZM could mitigate the effects of climate change in urban areas, e.g., taking over part of the water from the rainwater drainage system, which could be used during periods of drought. In addition, water reservoirs and their surroundings could help city dwellers survive long periods without precipitation and high temperatures. An important supplement should also be the use of the ecosystem services of water reservoirs, including water purification and the retention of phosphorus, nitrogen and carbon in sediments.

3. Materials and Methods

3.1. Geospatial Data Collections

Vector layers in the shapefile format, which present the land cover with water, provided the input data. They were clipped to the boundaries of Katowice (Figure 1), and previously extracted from the following databases:

- Corine Land Cover 2018 (CLC), a cover element defined by codes 511 (watercourses) and 512 (water reservoirs) [35]. This is a land cover inventory for the European region, divided into 44 classes in the years 1990–2018. The data was published in four editions and the most recent one from 2018 was used in the article [36]. The classification was made as part of the EU Copernicus program, using the method of visual interpretation of satellite images, hence the scale to which this database corresponds is 1:10,000 [37].
- Urban Atlas 2018 (UA), cover elements marked with the code 5000 (water) [38]. This was the first project in which area monitoring was carried out in "hot spots" (several hundred cities in the European Union and EFTA). The land cover classification was also performed under the Copernicus project using a combined method:(statistical) image classification and visual interpretation. The input data were satellite images of the SPOT 5 and 6 and Formosat-2 missions with a spatial resolution (GSD) of 2 to 2.5 m, hence the base corresponds to a scale of 1:1000. Data on the land cover were published in three editions, of which the last one from 2018 included 788 functional urban areas (FUA) with a population of 50,000 or more, for which 27 classes of land cover were distinguished [38,39].
- Database of Topographic Objects 10 k (BDOT), a linear layer assigned with the SWRS_L code (river and stream) and a polygonal layer with objects marked with the PTWP code (surface water) [40]. This is a database covering the land cover and location of other topographical objects (points, lines) in Poland. The resolution corresponds to a topographic map at a scale of 1:10,000. It was created and is being updated by the Head Office of Geodesy and Cartography as part of the Georeference Database of Topographic Objects project, and the national management system. BDOT is developed based on digital orthophotomap vectorization, field measurements and data from public institutions. The Database of Topographic Objects is widely available as part of services and for download in vector form. It is reference data for strategic and planning purposes or in state administration [41–43].
- Map of the Hydrographic Division of Poland (MPHP), a linear layer of distinguished watercourses and merged polygonal layers: lakes_highlighted and lakes_nothighlighted [44]. It presents the Polish hydrographic network. Digital MPHP was created through the digitization and vectorization of analog maps of the hydrographic division of Poland. The digital version of this map consists mainly of linear layers presenting the course of natural watercourses. Lakes and water reservoirs are drawn as polygons. Currently, the MPHP layers represent the Polish hydrographic network at a scale of 1:10,000. This map is, among others, the basis for reporting to the European Commission and it is a reference source in studies created for the implementation in Poland of the aims set

by European directives: 2000/60/EC (the so-called Water Framework Directive) and Directive 2007/60/EC (the so-called Floods Directive). MPHP 10 is considered to be the basic reference hydrographic database in Poland [44–46].

- Register of Lands and Buildings (EGiB), based on the GML text-graphic file, a polygon layer was generated indicating the range of land use: "Wp"—land under flowing surface waters and "Ws"—land under stagnant surface waters [47]. This is a database covering Poland's territory, consisting of subject and personal data for plots, units and precincts. It is an element of the Polish spatial information system maintained for the society in accordance with the assumptions of the INSPIRE directive. EGiB includes information on land, buildings and premises as well as their owners and legal status. It is a reference register for local government administration for tax, social, land and mortgage registration purposes, and real estate management, and is the input data for spatial planning [47–49]. The geometry of the objects is based on geodetic measurements, hence the data in this database are highly precise. From the point of view of the research, the most important part of EGiB is the land classification, which regulates, among others, the possibility of civil transactions in real estate (marking the land with the use of "Wp"—flowing waters (in Polish: *wody płynące*) precludes, for example, the sale of a plot).

Due to the non-uniform embedding of the input data in space, the PUWG 1992 (CS92) code EPSG: 2180 was defined for all layers.

The above-mentioned data was obtained:

- from the public Copernicus Earth Surface Monitoring website: https://land.copernicus.eu/ (in the case of CLC and UA) (accessed on 15 January 2023),
- from the resources of the State Water Holding Polish Waters (in the case of MPHP),
- from a publicly available national geoportal: https://geoportal.gov.pl/ (in the case of BDOT) (accessed on 28 January 2023),
- from the public register of the Katowice City Hall Geodesy Office (in the case of EGiB).

3.2. NDWI

A satellite image taken on 28 March 2022 as part of the Sentinel-2 mission was used to verify the precision of publicly available remote sensing data. On that day, during the detection, the sky over the city of Katowice was clear (0% cloud coverage), which made it possible to exclude disturbances in the value of reflected radiation.

The satellite imagery in all available spectral channels was downloaded using the Semi-Automatic Classification plug-in dedicated to the Quantum GIS. Only channels B03 (Green = 560 nm) and B08 (NIR = 842 nm) were used. These were characterized by the highest available spatial resolution of GSD = 10 m. Due to the above-mentioned resolution, NDWI was calculated as the quotient of the sum and the difference between the green and shortwave infrared ranges [27]. In accordance with the available data and the adopted criteria, the NDWI indicator for the Sentinel-L2A satellite was calculated as follows:

$$\frac{(\mathrm{B03} - \mathrm{B08})}{(\mathrm{B03} + \mathrm{B08})}$$

The range of indicator values is from −1 to 1, where values below 0 are representative of all other areas than those covered by water. According to this variant of the NDWI, [50] surfaces covered with water are representative of an NDWI value > 0.3. Due to the registration of the image in the early spring period, no area was characterized by such high values. Therefore, it was assumed that the surfaces covered with water had NDWI values >0, in accordance with the original interpretation [26,50]. ArcMap 10.7.1 software was used to process satellite imagery into polygons determining the occurrence of water. Multispectral images were recalculated with a raster calculator. A tool for reclassification and raster conversion into a vector layer was then used.

3.3. Spatial Multi-Criteria Analysis

The analyzed surface water databases are a set of input variables to determine the differences in land covered by water in Katowice.

The analysis of the resulting geoinformatics products (land cover—surface waters and watercourses—lines) made it possible to assess the occurrence of differences for individual databases. Using MapInfo 2019.3 Software (hexagon tools), each layer of drawing surface water firstly was clipped to the Katowice city border and then implemented into the grid of basic fields (an equal-area hexagon grid). Thanks to this, for each of the 313 basic fields, a comparison was made of the polygon area (which represented land used by water). In the case of polylines, the length of the watercourse fragment that flows through a given hexagon was compared (Table A1, Figure A6).

Using the grid based on equal-area fields allows us to make an objective database comparison. The hexagon gives the best results as opposed to other shapes because they are the most circular-shaped figures, which allows the creation of evenly spaced grid. This property has the effect of reducing sampling errors. Hexagon also conforms more easily to irregular boundaries and their centroids are closer to each other than those of other shapes. The adopted grid model has the following parameters: field shape—hexagon, area of the field equal to 648,180 m^2 and a width of 500 m. The set hexagon width was matched to the regional research extent.

The final result of the analysis is a map classified using the Natural Breaks (Jenks) method. This method is characterized by the separation of groups with maximum internal coherence that differs from the others—in the case of our research it indicates the greatest discrepancies in the land cover occupied by surface waters (Figure 2).

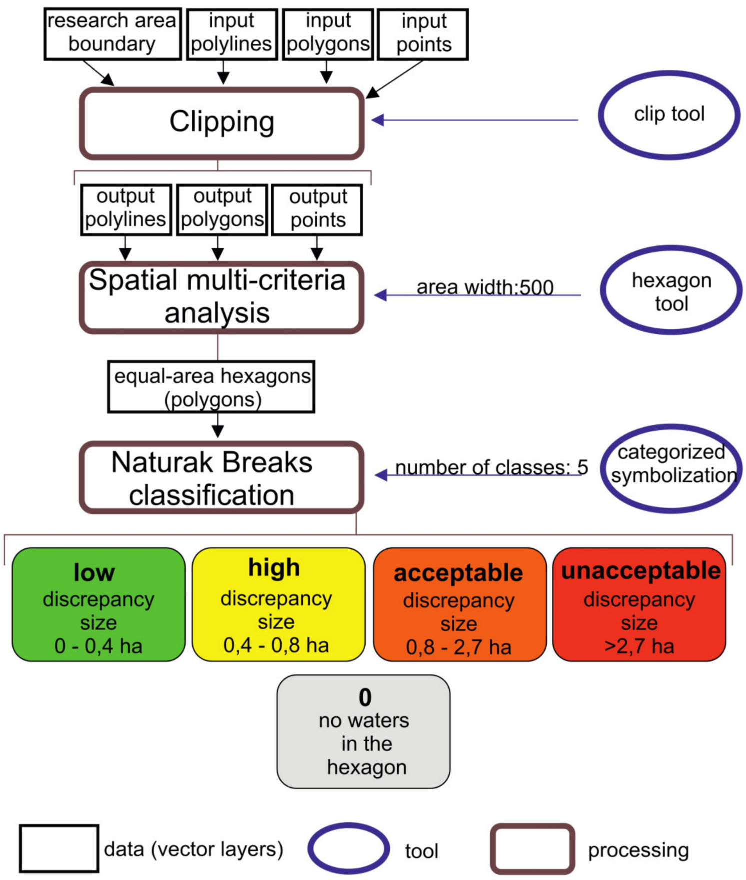

Figure 2. Flow chart of the adopted multi-criteria analysis of the different type of data.

Figure 2 presents every step taken to generate objective data being part of multicriteria analysis, starting from layer preparation till final classification (and its assumptions).

The input data wasn't distributed evenly and the maximums were outlier values, so Natural Breaks (Jenks) was believed to be the best classification base. In order to maintain unity in each comparison, five classes were used with uniform discrepancy values estimated based on discrepancies between the most precise among the examined databases, which are EGiB and BDOT (similar also to UA). The Natural Breaks (Jenks) classification method was also chosen among others (histogram equalize, equal intervals, quantiles) because it compared with basic statistical values (the second class corresponds to averages, the third class was similar to standard deviations and the fourth class corresponds to maximum values). The minimum values in each comparison were 0. The classification methods are described in detail below.

Considering that none of the compared databases could show complete convergence, the following classes were adopted (Figure 2):

- 0—characterizing hexagons in which none of the compared databases indicated the presence of surface waters,
- Low—characterizing hexagons in which the discrepancy value was greater than 0 but maximally equal to 0.4 ha; this range was estimated using the method of Natural Breaks (Jenks) and the upper value corresponded to the average discrepancy between EGiB and BDOT; it was assumed that such a size of discrepancies between databases does not disturb the analyses,
- Acceptable—characterizing hexagons in which the discrepancy value was in the range of 0.4 ha to 0.8 ha; it was estimated using the Natural Breaks (Jenks) method, and the upper value corresponded to the standard deviation of the discrepancy between EGiB and BDOT; it was assumed that while such a size of discrepancies between databases may disturb the analysis, it is still acceptable,
- High—characterizing hexagons in which the discrepancy value was between 0.8 ha and 2.7 ha; it was estimated using the method of Natural Breaks (Jenks), and the upper value is equal to half the maximum discrepancy between EGiB and BDOT; it was assumed that such a size of discrepancies between databases indicates the need to improve data,
- Unacceptable—characterizing hexagons with a discrepancy value greater than 2.7 ha. This is a critical value excluding the simultaneous use of considered databases in the analyses.

4. Results

4.1. Polygon Layers

In order to detect the places of the greatest discrepancies, each of the five databases was compared to one another. The resulting maps are presented in the Appendix A (Figures A1–A5) below.

The most precise and up-to-date database among those examined was the Register of Lands and Buildings (EGiB), which reaches critical values in the northeastern part of Katowice (the area with the largest surface anthropogenic reservoirs). High values of discrepancies occur between EGiB and other bases (CLC, UA, MPHP, BDOT) along the course of the Rawa River and its tributary, the Potok Leśny, as well as in the western part of Katowice (on the border of the city with Ruda Śląska) near the mouth of the Ślepiotka into the Kłodnica. Critical values of discrepancies between all databases are visible in the vicinity of reservoirs located in the above-mentioned Potok Leśny. In the case of comparing EGiB with UA and MPHP, critical values were noticed in 10 basic fields, and in the case of comparing EGiB with BDOT and CLC only in eight hexagons. Average (acceptable) discrepancies between these databases were explored for fields along the course of the Rawa. Fields occurring in the places where other rivers run (including the area of reservoirs located on the Potok Leśny) were characterized by low values of discrepancies between EGiB and MPHP (up to 0.4 ha). High values of discrepancies between EGiB and similarly CLC and UA occurred along the entire course of the Rawa and in most fields including the Kłodnica riverbed (outside the spring area) (Figure A1).

Comparing the BDOT with the CLC, clear discrepancies are noticeable in the areas of water reservoirs and the entire course of the Potok Leśny. When analyzing the BDOT and EGiB databases, differences in the land cover area of more than 0.4 ha prevail in places where watercourses run. Comparing the BDOT and UA databases, a critical discrepancy occurred only in one field in the northeastern part of Katowice, where no rivers run, and 16 fields non-uniformly distributed in space were characterized by discrepancies between 0.8 ha and 2.7 ha. MPHP has the most consistent data compared to BDOT (no critical values, and high discrepancies occurred in 5% of cases) (Figure A2).

The MPHP polygonal layer contained only data on water reservoirs; therefore, when compared with the EGiB, as many as 16% of the basic fields located along the course of rivers were characterized by high discrepancies. Critical values were recorded in 10 fields, all related to the presence of water reservoirs. An unacceptable discrepancy was found in only one field located outside flowing waters when comparing MPHP and UA, and more than half of the fields had a value of 0 (Figure A3).

The Corine Land Cover is a small-scale database, therefore flowing waters (code: 511), which occur in relatively narrow or covered beds, have not been identified in the area of Katowice. This means that when comparing with the MPHP (layer with reservoirs only), values of 0 were recorded in the course of Rawa, and all critical discrepancies were noted in the areas of large water reservoirs. Surprising results of discrepancies between EGiB and CLC (low or acceptable) show hexagons located in the place of watercourses, which—due to the lack of the CLC layer code 511—is caused by a small share of the water (Wp) in the hexagon area. Critical discrepancies occur when comparing these bases within water reservoirs. However, in the case of the Przyrwa or the Pstrążnik, the hexagon values are equal to 0, which indicates that according to EGiB (which is the administrative reference record), the land covered with these watercourses has not been classified as land covered with surface waters (Figure A4).

Comparing the Corine Land Cover and the Urban Atlas, a high percentage of basic fields in which databases do not indicate the presence of any surface waters (86%) was observed. The predominance of high discrepancies and critical values in the areas of water reservoirs was also noticed: only in seven hexagons are there discrepancies equal to a maximum of 0.4 ha, and in four they reach a maximum of 0.8 ha (Figure A5).

4.2. Remote Sensing Data and Analyzed Databases

The above-described results of the comparison of existing land cover databases showed numerous discrepancies in water-covered areas. Therefore, the user is forced to look for alternative sources indicating the actual (current) extent of surface waters. The possibility of using publicly available satellite images of the Sentinel L2A mission (taken in a 5-day time interval) for this purpose was verified. From this imagery using the NDWI index, water-covered areas were separated and converted to a polygon layer, thus creating a real-time land cover layer.

In this case, land covered by water was not identified in 37% (116 out of 312) of the base fields. Convergence trends of the generated data were similar for each of the compared databases, as evidenced by the similar values of basic statistical values (Table 1).

Table 1. Basic statistical values due to database comparison.

	NDWI-EGiB	NDWI-BDOT	NDWI-MPHP	NDWI-UA	NDWI-CLC
mean	6422.702	5000.137	5159.359	4896.363	6383.894
median	1787.657	1097.471	1268.202	818.174	818.174
max.	100,739.9	76,363.75	77,740.87	79,001.77	11,2596.6
min.	0	0	0	0	0
standard deviation	12,233.33	9391.076	8875.003	9577.242	14,083.88

Source: own study.

Therefore, it is impossible to distinguish the database with which the generated land cover information coincides the most. In each case, the NDWI values were characterized by relatively low discrepancies in the spring areas of the Kłodnica, the Ślepiotka and the Mleczna. The generated data was critically inconsistent with all databases in the northeastern part of Katowice, where there are many large-area water reservoirs. In addition, in the entire course of the Rawa, the generated values were highly divergent compared to the BDOT, EGiB, MPHP, UA and CLC databases, especially in the central part of the city in the vicinity and below the mouth of the Potok Leśny into the Rawa (Figure 3).

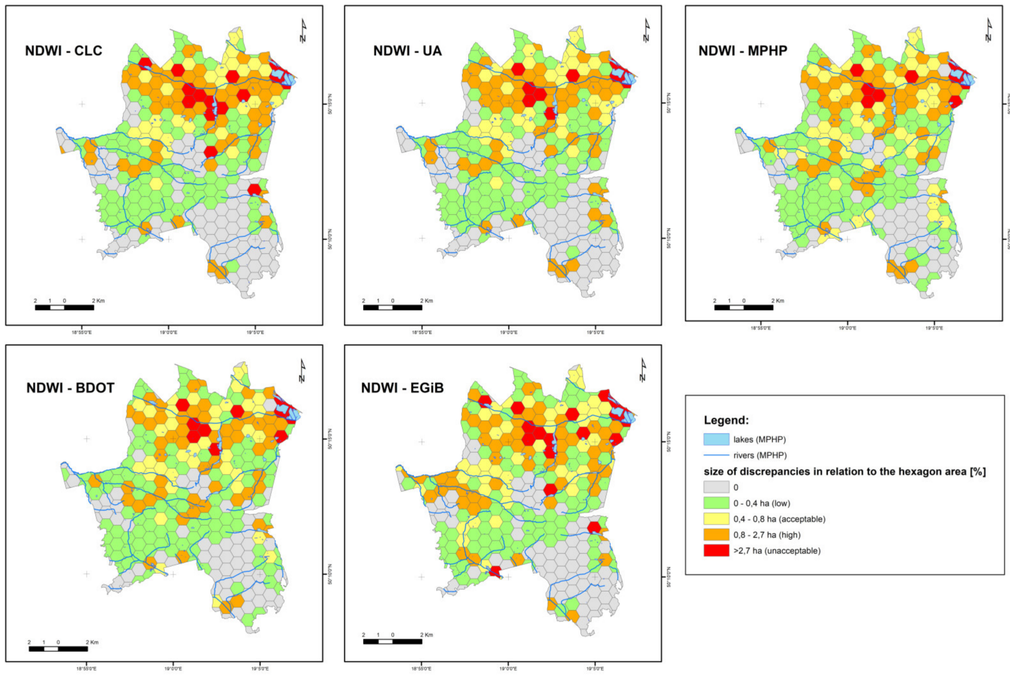

Figure 3. Comparison of polygons generated based on NDWI with other databases in the grid of basic fields. Source: own study.

4.3. EGiB in Relation to Linear Layers

As the name suggests, the method of multi-criteria spatial analysis allows for the validation of various data types. While examining the analyzed databases, a comprehensive comparison was made. This also included the occurrence (indicated by the length of the polyline) of watercourses in relation to the size of land cover with flowing waters. For this purpose, the most up-to-date and precise Register of Lands and Buildings was used (using only data on the land use of "Wp").

As indicated in the introduction, the analysis is carried out on a local scale for the city area, which excludes significant changes in the riverbed width. The area of land occupied by flowing waters should therefore be directly proportional to the length of the line presenting the course of the river. As shown in the graph (Figure 4), both the BDOT database and the MPHP database in the basic fields—where, according to EGiB, there are no surface waters—indicate the presence of watercourses with a length exceeding 4 km inside the hexagon. In six hexagons, in which EGiB indicates the presence of areas covered with water, there is no line presenting the watercourse according to MPHP and EGiB. In the grid of basic fields (hexagons), where there are both polylines of rivers and land used by flowing water (Wp), the discrepancy in the lengths of these lines is several km, and any length value increases proportionally to an area occupied by water (Figure 4).

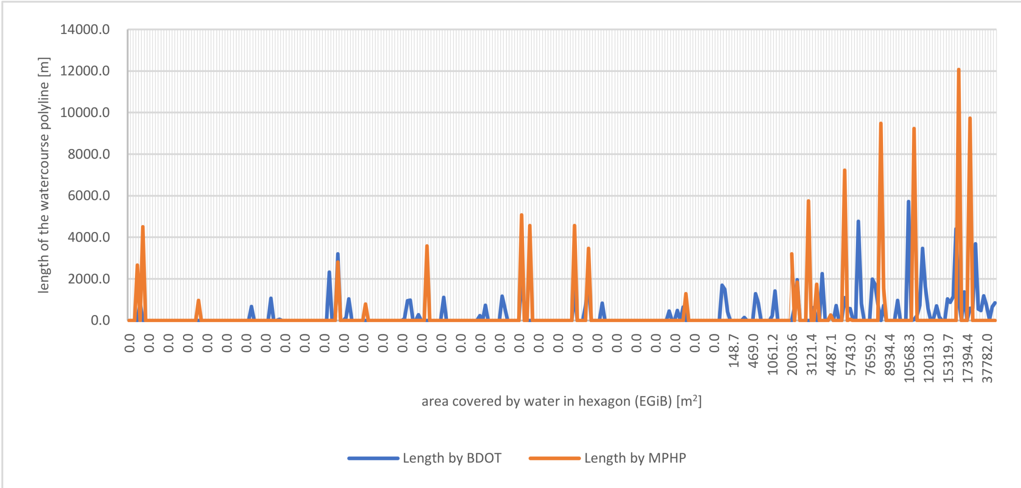

Figure 4. comparison of the length of the BDOT and MPHP lines with the area covered by water according to EGiB.

In the case of: Przyrwa, Pstrążnik, as well as in the basic fields covering the spring areas of Potok Leśny, Kłodnica, Ślepotka, Bolina, no areas covered with surface waters were marked in the Land and Building Register (Figure 5). It should also be noted that the spring area of the Bolina is located, according to BDOT and MPHP, in different hexagons. This is also the case with the Przyrwa. As they move downstream, the area covered by the flowing waters of the rivers Kłodnica, Ślepotka, Mleczna and Bolina, according to EGiB, increases. The "Wp" land-use area is drawn along the entire course of the Rawa, but its area is varied; in the eastern part of Katowice it is about 2 ha, in the middle course it is less than 0.5 ha, and in the lower section it is about 1 ha. The Register of Lands and Buildings indicates that the largest area covered by waters flowing in Katowice is in the vicinity of the reservoirs located on the Potok Leśny (Figure 5).

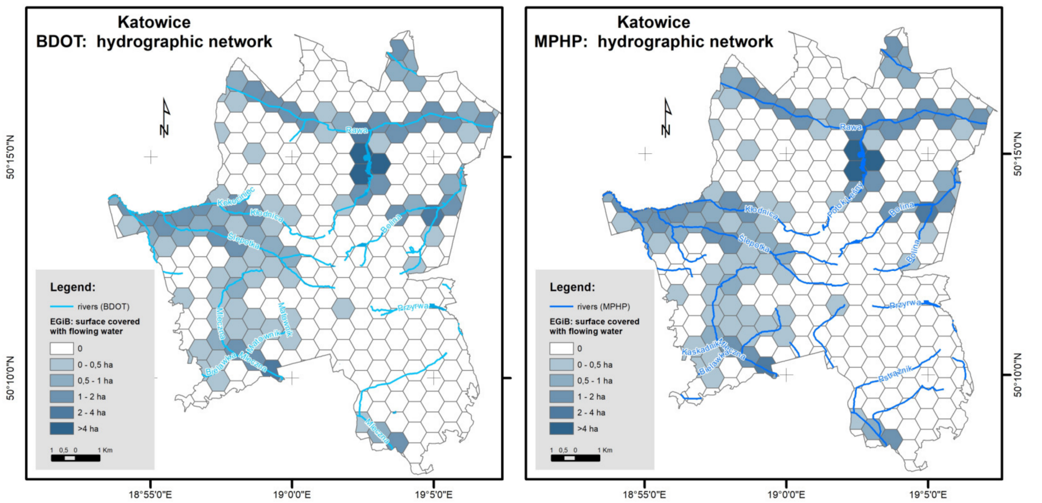

Figure 5. Hydrographic network in Katowice by BDOT (**left**) and MPHP (**right**) on the background of EGiB data.

5. Discussion

Due to the wide use of the land cover database in local-scale scientific research, Cieślak et al. [51] indicate the Corine Land Cover as a reliable source of temporal variability of spatial development in the region of Warmia and Mazury. whereas Z. Debesova [52] uses the Urban Atlas to identify morphological similarities between European cities.

Similar studies were conducted by P. Szarek-Iwaniek [53]. In the example of Olsztyn, the author compared, e.g., CLC and UA with official sources of land and cadastre coverage, using the BDOT and EGiB databases [43,47]. The conclusion of this work indicated the differences in timeliness and detail (generalization), the diversity of nomenclature and land cover classes, the problem of lack of data and the careful selection of the input data due to the scale and scope of research. The issue of the land cover database's validity and the precision of mapping the actual state applies in particular to the surface hydrographic network, which is dynamic. For this reason, studies related to the validation of databases covering surface water areas in highly urbanized terrain were undertaken.

I. Manakos et al. [54] are among global authors who indicate the problem of discrepancies between surface water area extent in different databases and other materials based on satellite and aerial remote sensing. Due to the shading of rivers with tree crowns, weather conditions (clouds, precipitation), or the watercourse in piped sections, all spatial databases relating to areas covered with water are inconsistent [55].

The lack of precision of data regarding water coverage is emphasized by, e.g., K. Kowalski [56], who notices the problem of defining flowing waters, which (according to the Regulation of the Minister of Development, Labor and Technology on EGiB [47]) are waters in a water reservoir located on a natural riverbed. For this reason, the Land and Building Register (EGiB) showed high discrepancies with other databases in the basic fields beside the Potok Leśny, where water reservoirs were located.

Differences resulting from the interpretation of the Water Law [2] and the Regulation on the EGiB [47] are visible in the example of the course of the Przyrwa and Pstrążnik watercourses defined by the MPHP, where in any of the basic fields under these rivers there was no area designated for land use "Wp". It should be noted that according to M. Barczyńska et al. [46], the MPHP is the official source of the Polish hydrographic network. However, no administrative authority has issued a decision specifying the nature of the above-mentioned watercourses.

In the case of the rivers Kłodnica, Ślepotka, Mleczna and Bolina, the surface area covered by flowing waters according to EGiB increases with the course of the river. This shows the high precision of EGiB related to the increase in the area occupied by flowing waters as the river bed expands. This regularity does not occur in the case of the Rawa, which in the center of Katowice flows partly in a piped section. Determining the width of the riverbed in the piped section, and thus the area characterized by the use of "Wp", is indicated as a problematic issue in Polish water and spatial management [55].

P. Śleszyński et al. [57]. when comparing CLC and BDOT for the entire Poland territory, find a high inconsistency of land cover classes. Areas covered with water are defined by the BDOT "PTWP" layer, while in the case of CLC, two classes have been distinguished, corresponding to the total coverage with surface waters, 511 (Water courses) and 512 (Water bodies), with no objects in Katowice assigned to the class "511". In addition, the MPHP polygon layer indicated only water reservoirs and did not cover areas of flowing water. Apart from this case, there was a complete correlation of the data range of the compared databases. The greatest discrepancies between CLC and BDOT were found in the areas of lake districts [49]. In the case of Katowice, all the compared databases were characterized by critical discrepancies in the water reservoir areas.

As in the case of Szarek-Iwaniuk [53] and Śleszyński et al. [57], the main reason for the discrepancies was the scale of development of individual land cover databases, especially when comparing small-scale CLC and UA studies based on satellite imagery with EGiB based on empirical analyses and geodesic measurements. Although in the basic fields covering the Rawa and Kłodnica riverbeds, the discrepancies between the EGiB and the CLC and UA were classified as low and acceptable, they were equal to the value of the area of the "Wp" class.

In addition, the city of Katowice, according to M. Rzętała [33] is part of the Upper Silesian anthropogenic lake district. Many post-mining reservoirs, settling tanks and water-filled basins have not been classified, and changes in their extent depend on locally occurring land deformations. Due to the continuous process of formation, changes in the shoreline, or diversified genesis of the uprising, some reservoirs are not classified as water areas (e.g., according to EGiB, these are agricultural areas, meadows, wastelands) [27], or their range is valid only on the date of the drawing. The studied databases were created and updated in different periods, and remote sensing data show the most current range of surface waters, hence the discrepancies in the fields covering the areas of anthropogenic reservoirs are the largest.

Similar to the presented research, validation of cadastral data and Urban Atlas with the use of statistical tools and based on thematic and spatial aggregation was carried out for the metropolitan area of Prague [58]. As a result of this research, less differentiation between these two bases was found in areas covered with water, agricultural and forest areas than in built-up areas or low green areas, and also indicated that the cadastral data needed to be updated. Czech cadastral data correspond to the Polish register of land and buildings, which in turn is constantly updated [47,56] but in the areas of surface waters, it differs significantly from the Urban Atlas. In areas of dense development, these differences in surface waters increase. Relatively similar spatial information of land cover with water is found between Urban Atlas, BDOT and MPHP.

The multi-criteria spatial analysis made it possible to determine the highest compliance of land cover with surface waters according to BDOT and MPHP (these databases were often a source for each other) [46]. In the case of MPHP, the polygon layer covered only water reservoirs and comparing the MPHP and BDOT linear data, the source sections of the Bolina and Przyrwa rivers were located in different basic fields.

It has been proven that the problem of the proper definition of land cover with surface waters is a complex issue in technical, formal, and legal terms. The reliability and up-to-dateness of databases may also be a limitation in the conducted research [59] and a challenge in the implemented activities in proper water management. When implementing assumptions to the Water Resource Development Program [60] in Poland and other investment and maintenance works aimed at increasing water retention in the context of counteracting the effects of drought, it is also essential to know the land cover and reliable registers of water facilities in the analyzed area (e.g., their type, purpose, and owner). According to [58], geoinformation tools and remote sensing data are needed to update land cover data. The need to constantly update the existing land cover databases is primarily caused by the high dynamics of changes in the surface hydrographic network, especially in areas of intensive urbanization and under the influence of underground mining activity.

The material supporting real-time land cover analyses can be data obtained from current satellite images (especially since these images are widely available). Technological development of geoinformation systems and remote sensing methods allows the use of deep learning algorithms for continuous monitoring of changes in land cover (Land Use and Land Cover) on a local scale [61]. However, the quality of data (image resolution) is the limitation. Due to the multi-criteria spatial analysis, it was possible to verify to what extent the spatial information generated from a commonly available satellite image coincides with the data, e.g., obtained as part of geodetic modernization works. The NDWI index used for this purpose, which is widely used in the detection of surface waters and wetlands as well as their modification, was tested by [62]. W. Li et al. [63] indicate the highest efficiency in the detection of surface waters using the green and mid-infrared range. For remote detection of surface waters in Katowice, a modification of the indicator based on channels 3 and 8 of the Sentinel-2 satellite was used. We have suggested, similarly to Y. Du et al. [62], higher resolution of these channels compared to other publicly available data. Geographic Information Systems were used to process the photos, as done in 2013 by S. McFeeters, the creator of the original modification of the indicator [49].

Detection of areas covered with water using the NDWI turned out to be particularly useful in basic fields located in the source areas of rivers, where the compared databases did not show the presence of surface waters. The occurrence of surface waters was detected in hexagons located along the Ślepotka and Kłodnica rivers. Along the Rawa riverbed, the water coverage was not so clearly indicated. Referring to the observations made by [47], this is related to the course of the Rawa river, partly in the piped section, as well as the shading of the area with high buildings.

The research results indicate that surface waters were mostly indicated in the fields where the analyzed databases also showed their presence. The greatest discrepancies were detected in the places of water reservoirs. They are related to the above-described database errors and the variability of water levels in watercourses or water reservoirs depending on hydrological and atmospheric conditions (precipitation amount, inflow volume) valid for the date of photo registration. This method is an appropriate approach to obtain data on the current state of hydrography on a local scale; however, one should remember the limitations related to the resolution of input data and the availability of cloudless images. On a local scale, these limitations can be eliminated by using aerial imagery, including those taken with the use of Unnamed Aerial Vehicles (UAV) [64]. Additionally, for Corine Land Cover and Urban Atlas, an analogous methodology based on autoclassification of satellite images was used [17].

6. Conclusions

This article validates the most widely used land cover databases available for the city of Katowice. For this purpose, a spatial multi-criteria analysis based on a grid of equal-area basic fields was used. The compared databases were created based on input materials with different resolutions. The classification was therefore generalized. However, the proposed method based on threshold data estimated with Natural Breaks (Jenks) is a perfectly adequate way to test the compatibility of local surface water databases, such as EGiB, BDOT or MPHP.

The basis for spatial multi-criteria analysis is the proper selection of the range of basic fields. Due to the comparison of regional and local data, it happened that the hexagon value was based only on the share of the area covered with water according to one database, while according to the other database (mainly CLC), there was no water in this field at all.

In the water-covered areas, the analysis showed the greatest convergence of the BDOT and MPHP databases (created on the basis of each other). These bases were relatively consistent with the Urban Atlas. The highest discrepancies occurred when comparing Corine Land Cover with other databases, related to the varied scale of the studied databases.

High discrepancies were detected by comparing EGiB with other databases. It should be noted that this is the most precise and up-to-date source of spatial information on water-covered land. Incorrect data in the Land and Building Register have formal and legal consequences (e.g., related to restrictions on construction investments, civil law transactions in real estate, or ownership issues). The discrepancy between these data with surface and linear BDOT and MPHP data is therefore worrying. It should be highlighted that MPHP and BDOT are provided by state offices as reference data for land cover and hydrographic networks.

The research also showed that places covered with water according to NDWI were located in the same basic fields where the occurrence of surface waters was indicated by the compared databases. In the case of satellite data, there are limitations related to the low resolution (GSD = 10 m) and the availability of appropriate images (registered on a cloudless day). In local analyses, these limitations can be eliminated by obtaining aerial multispectral images. Processing such materials using geoinformation tools and the NDWI will make it possible to successfully indicate the range of areas currently covered with water, which is particularly important considering the dynamics of land cover changes in the analyzed area.

The proposed multi-criteria spatial analysis can be used on large scale by Geodesy and Cartography Departments to verify the compliance of EGiB data with other surface water databases or with its actual state.

Based on the results of the presented research as well as the analysis of the literature, we have prepared a scheme for selecting the optimal database depending on the purpose of the study (Figure 6). This diagram applies to databases available in Poland. However, it can also be related to similar local water cover databases in other countries. It should be emphasized that this diagram applies only to databases in the context of water land cover (the accuracy of other land cover types has not been verified in our research).

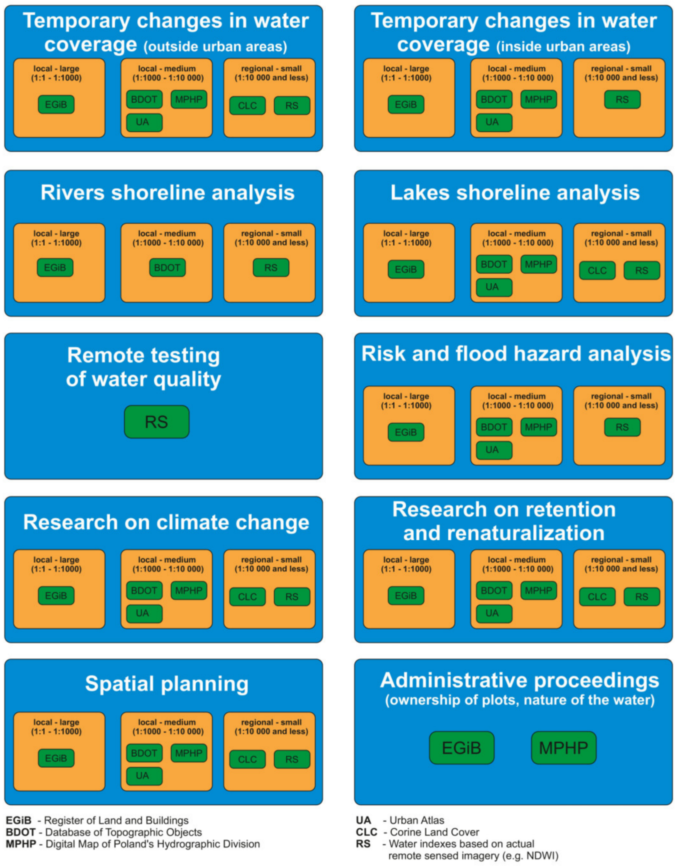

Figure 6. Recommended surface water databases depending on the type of analysis. Source: own study.

However, the presented methodological solution for the validation of existing land cover data with surface waters and their updating needs to solve the problem of proper classification of natural and artificial flowing and stagnant waters, as well as verification of the course of rivers in covered sections. For this reason, further interdisciplinary research in hydrography, hydrology, law, remote sensing, geoinformation and spatial development is necessary.

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Data Availability Statement: Publicly available data sets were analyzed in this study. These data can be found here: https://www.geoportal.gov.pl/dane/baza-danych-obiektow-topograficznych-bdot (accessed on 28 January 2023); https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018 (accessed on 15 January 2023); https://land.copernicus.eu/pan-european/corine-land-cover/clc2018 (accessed on 15 January 2023); https://docs.sentinel-hub.com/api/latest/data/sentinel-2-l2a/ (accessed on 23 January 2023).

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Figures visualize database comparison with each other by spatial multi-criteria analysis.

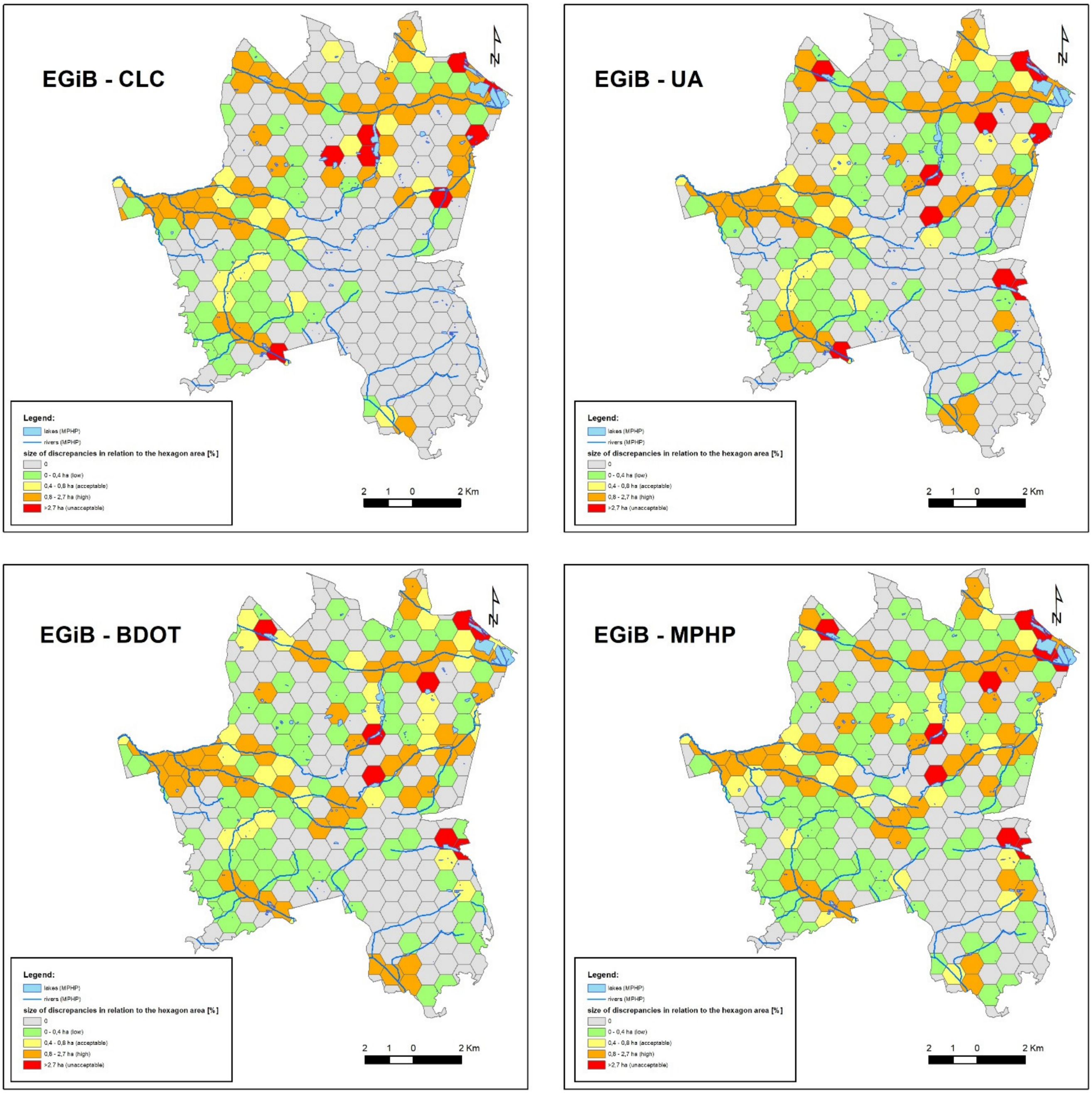

Figure A1. Spatial multi-criteria analysis—comparison of Register of Land and Buildings (EGiB) with other studied land cover databases.

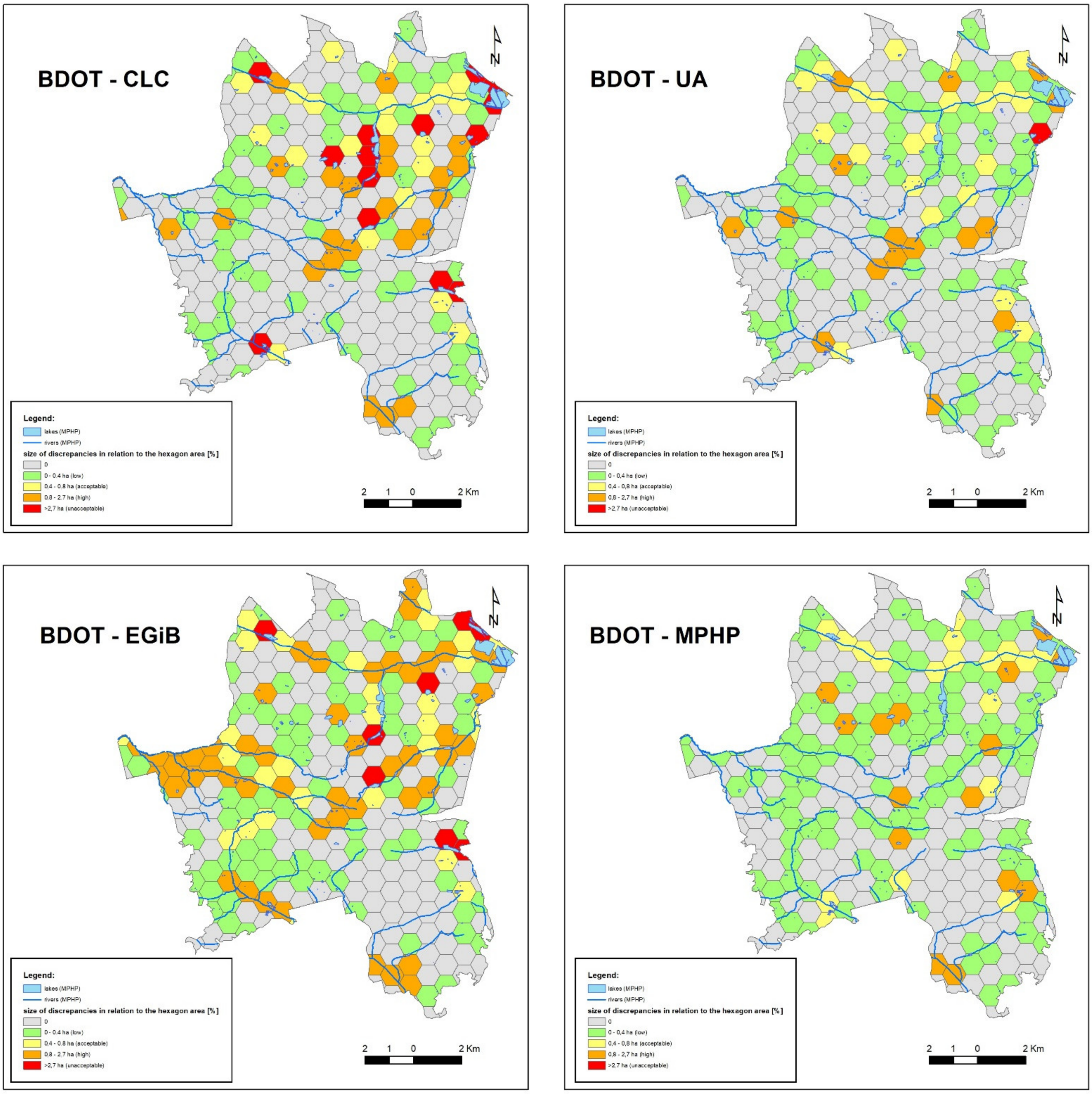

Figure A2. Spatial Multi-criteria analysis—comparison of Database of Topographic Objects (BDOT) with other studied land cover databases.

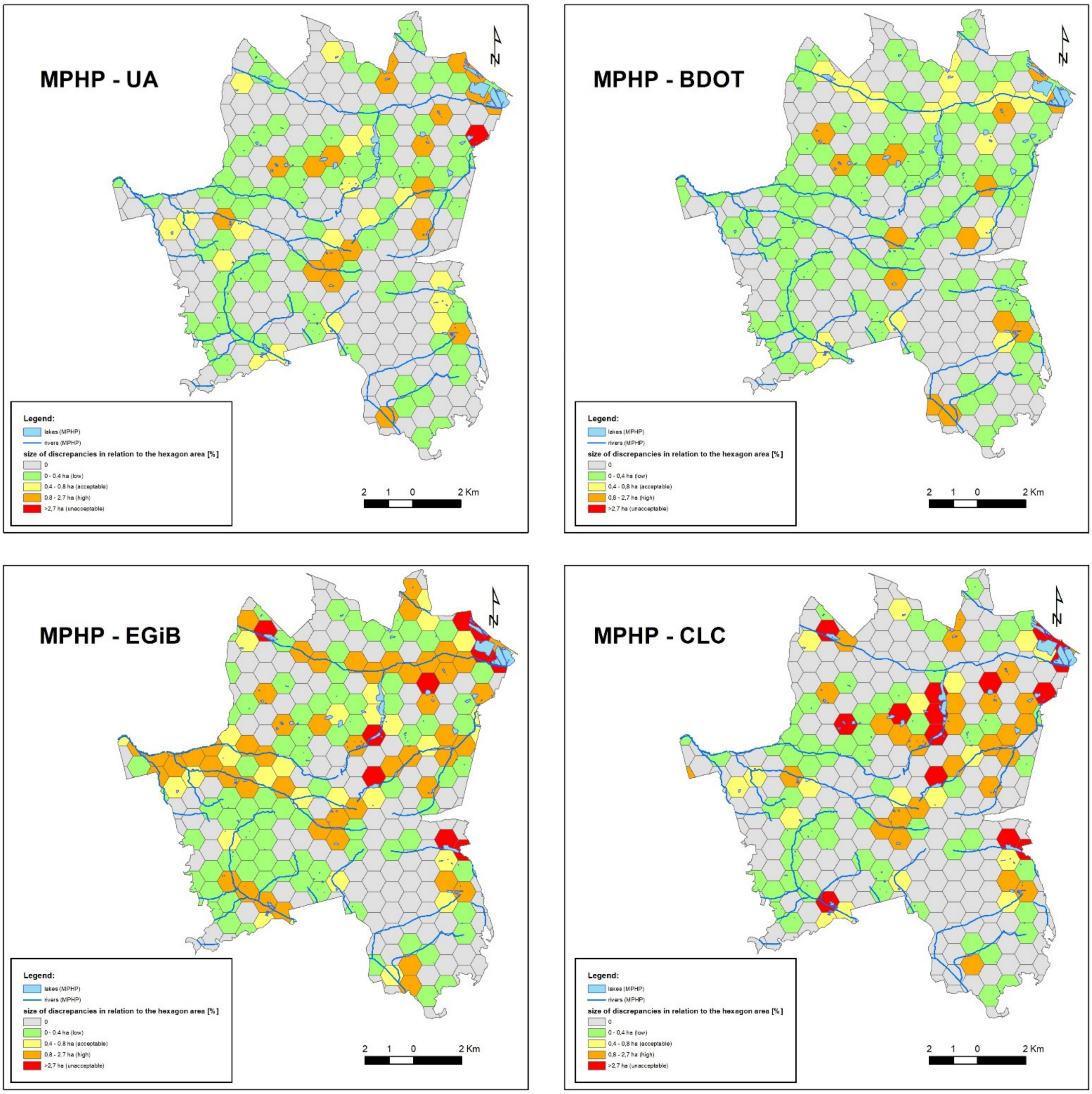

Figure A3. Spatial multi-criteria analysis—comparison of Map of the Hydrographic Division of Poland (MPHP) with other studied land cover databases.

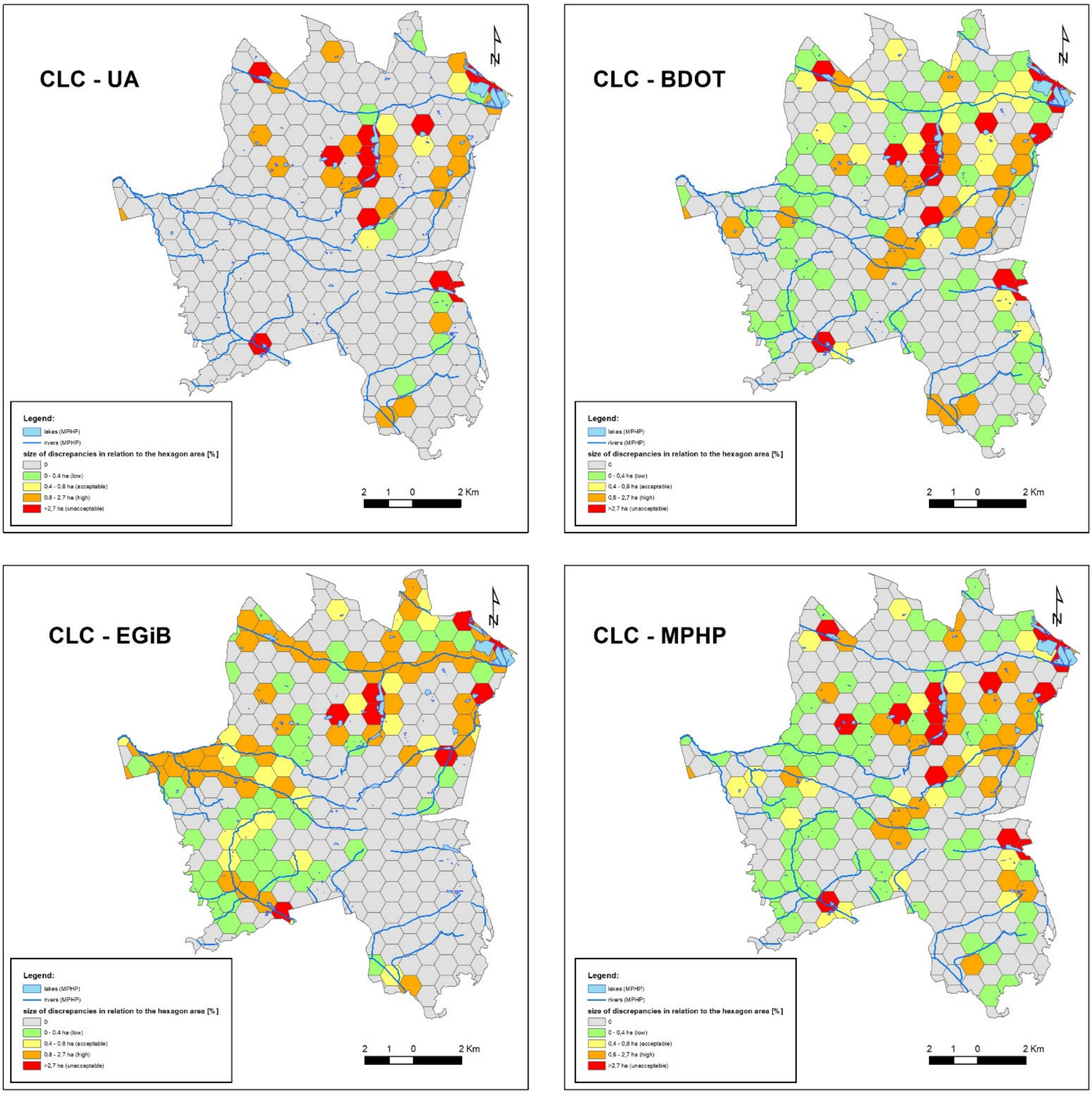

Figure A4. Spatial multi-criteria analysis—comparison of Corine Land Cover (CLC) with other studied land cover databases.

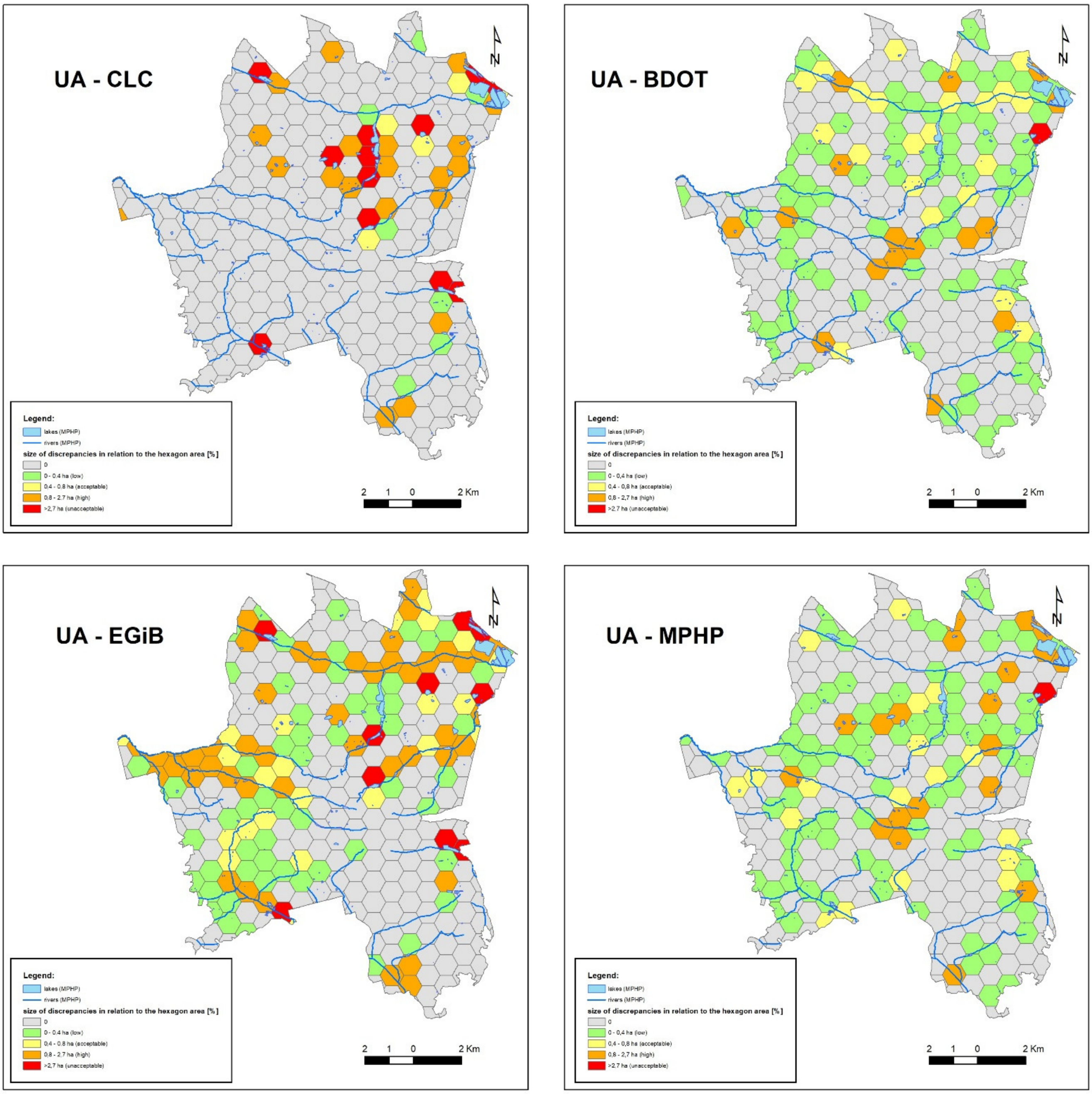

Figure A5. Spatial multi-criteria analysis—comparison of Urban Atlas (UA) with other studied land cover databases.

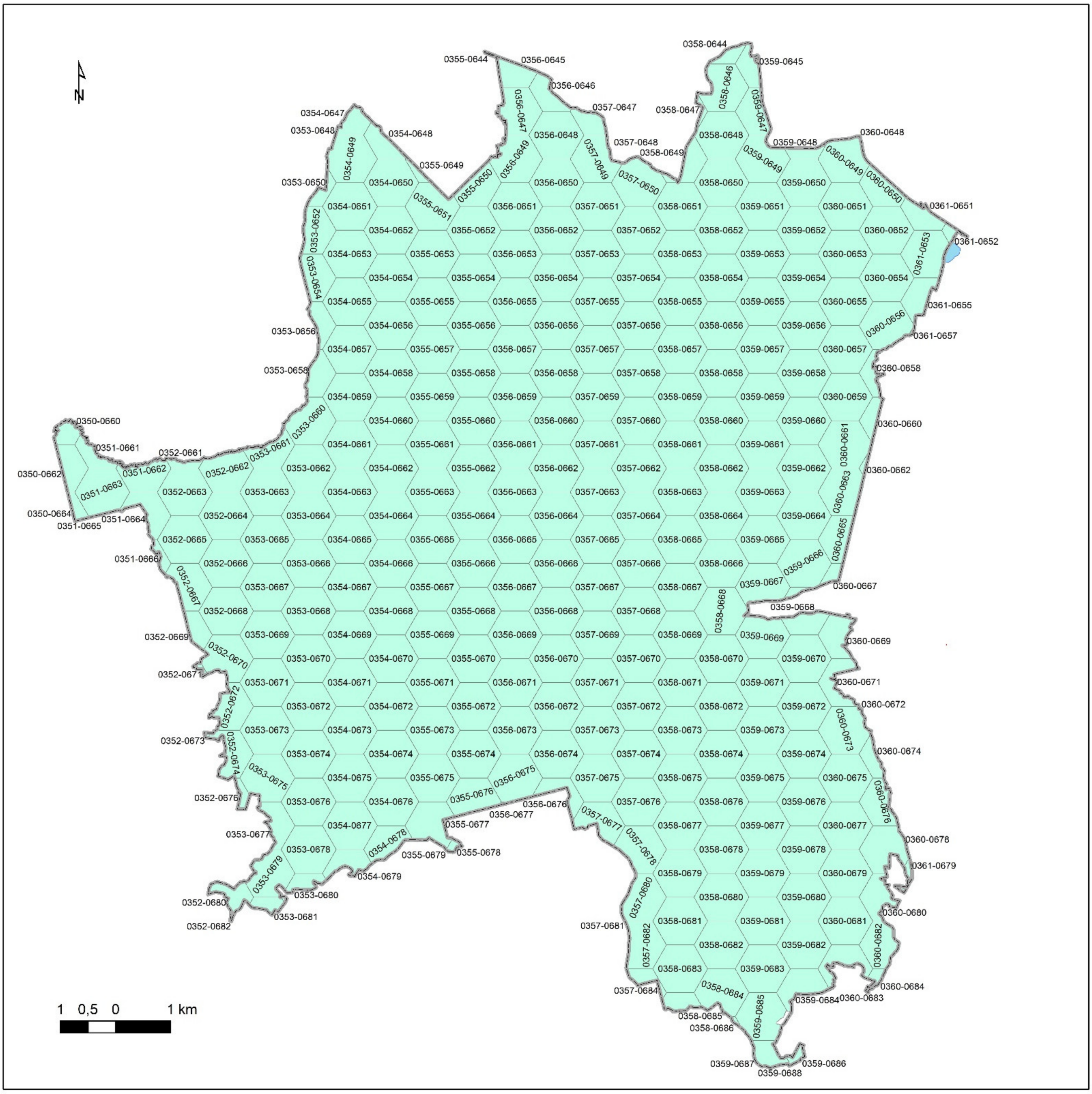

Figure A6. Location of hexagons—numbering in relation to Table A1.

Table A1. Areas covered by water and river length in individual hexagons.

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0350-0660	167,745.91	5743.03	0.00	78.97	0.00	0.00	0.00	566.94	49.72
0350-0662	312,553.38	0.00	313.04	0.00	0.00	0.00	0.00	0.00	0.00
0350-0664	101,987.40	0.00	0.00	0.00	0.00	16,217.94	0.00	0.00	0.00
0351-0661	210,448.33	11,327.85	0.00	0.00	0.00	0.00	0.00	730.73	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0351-0662	415,757.26	11,977.32	0.00	310.95	0.00	0.00	272.98	1638.06	0.00
0351-0663	628,665.11	431.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0351-0664	37,2841.17	8071.92	0.00	0.00	0.00	0.00	2511.35	782.38	0.00
0351-0665	2332.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0351-0666	88,207.48	780.58	0.00	0.00	0.00	0.00	0.00	845.03	0.00
0352-0661	88,009.04	12,978.89	405.77	0.00	0.00	0.00	0.00	698.25	0.00
0352-0662	552,236.25	12,013.01	0.00	0.00	0.00	0.00	1091.94	570.29	0.00
0352-0663	649,516.24	11,351.66	0.00	0.00	0.00	0.00	8582.76	0.00	0.00
0352-0664	649,516.24	11,788.74	2318.68	4250.65	0.00	0.00	0.00	0.00	0.00
0352-0665	649,516.24	148.75	8833.44	7950.22	0.00	0.00	10,996.94	0.00	0.00
0352-0666	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2656.11
0352-0667	467,334.92	0.00	0.00	0.00	0.00	0.00	0.00	860.53	0.00
0352-0668	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4504.83
0352-0669	214,960.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0352-0670	573,809.46	1237.58	0.00	0.00	0.00	0.00	272.99	0.00	0.00
0352-0671	23,761.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0352-0672	427,109.41	0.00	0.00	0.00	0.00	0.00	272.99	0.00	0.00
0352-0673	7484.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0352-0674	401,719.27	454.77	432.05	797.46	0.00	0.00	272.99	0.00	0.00
0352-0676	86,475.55	994.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0352-0680	239,107.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0352-0682	26.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0648	442.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0650	135,889.84	886.42	266.93	0.00	0.00	0.00	378.58	0.00	0.00
0353-0652	397,590.53	0.00	0.00	0.00	0.00	0.00	16,119.90	0.00	0.00
0353-0654	389,638.75	349.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0656	234,716.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0658	300,304.13	0.00	674.96	588.39	0.00	0.00	0.00	0.00	0.00
0353-0660	563,294.10	5147.81	586.09	559.10	0.00	0.00	1092.09	704.13	0.00
0353-0661	371,646.99	14,688.03	0.00	215.09	0.00	0.00	811.16	171.04	0.00
0353-0662	649,516.24	7748.77	28.01	288.77	0.00	0.00	2348.08	0.00	0.00
0353-0663	649,516.24	9930.90	0.00	0.00	0.00	0.00	1357.21	0.00	0.00
0353-0664	649,516.24	23,329.28	9315.87	8698.25	0.00	0.00	921.75	5727.87	0.00
0353-0665	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0666	649,516.24	0.00	493.61	606.30	0.00	0.00	10,857.66	0.00	0.00
0353-0667	649,516.24	0.00	0.00	399.06	0.00	0.00	0.00	0.00	0.00
0353-0668	649,516.24	3501.55	2144.60	5324.17	0.00	0.00	2728.37	0.00	0.00
0353-0669	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0353-0670	649,516.24	5629.59	0.00	668.27	0.00	0.00	0.00	0.00	0.00
0353-0671	649,516.24	0.00	0.00	0.00	0.00	0.00	545.97	0.00	0.00
0353-0672	649,516.24	4685.47	1483.50	1484.24	0.00	0.00	273.06	0.00	0.00
0353-0673	649,516.24	1199.29	0.00	0.00	0.00	0.00	1119.21	0.00	0.00
0353-0674	649,516.24	10,806.18	1733.36	1950.11	0.00	0.00	273.10	0.00	0.00
0353-0675	630,456.97	3984.83	2514.55	630.68	0.00	0.00	2185.65	0.00	1741.05
0353-0676	649,516.24	2782.31	0.00	0.00	0.00	0.00	272.99	1957.19	1843.89
0353-0677	312,945.32	1123.58	957.75	907.92	0.00	0.00	0.00	0.00	0.00
0353-0678	649,516.24	1210.30	0.00	145.98	0.00	0.00	0.00	0.00	0.00
0353-0679	516,915.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0680	179,489.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0353-0681	133,181.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	956.62
0354-0647	219,810.52	0.00	0.00	0.00	0.00	0.00	272.99	0.00	0.00
0354-0648	257,082.57	3231.07	3266.40	2657.45	0.00	0.00	546.05	0.00	0.00
0354-0649	629,023.12	9336.09	2880.29	0.00	0.00	0.00	682.05	0.00	0.00
0354-0650	649,516.24	12,231.22	67,169.38	62,324.16	59,249.91	0.00	46,580.30	0.00	0.00
0354-0651	649,516.24	11,024.92	6447.95	6401.56	0.00	0.00	14,081.42	0.00	0.00
0354-0652	649,516.24	0.00	0.00	0.00	0.00	0.00	4429.54	0.00	0.00
0354-0653	649,516.24	0.00	0.00	0.00	0.00	0.00	11,436.81	0.00	0.00
0354-0654	649,516.24	0.00	0.00	0.00	0.00	0.00	12,551.21	0.00	0.00
0354-0655	649,516.24	0.00	0.00	0.00	0.00	0.00	3692.40	0.00	0.00
0354-0656	649,516.24	25,607.19	4325.91	12,836.72	10,114.49	0.00	819.24	0.00	0.00
0354-0657	649,516.24	0.00	768.27	910.41	0.00	0.00	0.00	0.00	0.00
0354-0658	649,516.24	0.00	190.36	0.00	0.00	0.00	1181.03	0.00	0.00
0354-0659	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0354-0660	649,516.24	0.00	0.00	0.00	0.00	0.00	5686.49	0.00	0.00
0354-0661	649,516.24	12,222.99	271.90	276.02	0.00	0.00	4813.71	3460.65	0.00
0354-0662	649,516.24	10,881.45	518.03	441.10	0.00	0.00	5040.84	36.53	9231.20
0354-0663	649,516.24	878.81	671.88	762.99	0.00	0.00	3828.69	0.00	0.00
0354-0664	649,516.24	5756.21	0.00	0.00	0.00	0.00	1092.11	0.00	0.00
0354-0665	649,516.24	17,070.09	3048.90	5644.91	0.00	0.00	2730.35	0.00	0.00
0354-0666	649,516.24	1253.62	0.00	0.00	0.00	0.00	10,351.57	0.00	0.00
0354-0667	649,516.24	1159.66	0.00	0.00	0.00	0.00	10,142.74	0.00	0.00
0354-0668	649,516.24	4000.29	0.00	280.72	0.00	0.00	3825.96	0.00	0.00
0354-0669	649,516.24	6385.94	840.86	2392.09	0.00	0.00	545.98	4768.82	0.00
0354-0670	649,516.24	429.20	355.50	383.87	0.00	0.00	3274.49	0.00	0.00
0354-0671	649,516.24	419.23	0.00	0.00	0.00	0.00	544.38	0.00	0.00
0354-0672	649,516.24	3121.38	0.00	0.00	0.00	0.00	819.02	0.00	0.00
0354-0673	649,516.24	2943.41	0.00	0.00	0.00	0.00	1076.37	0.00	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0354-0674	649,516.24	3979.28	0.00	0.00	0.00	0.00	561.51	2244.32	0.00
0354-0675	649,516.24	15,319.72	0.00	254.23	0.00	0.00	1365.17	1038.76	0.00
0354-0676	649,516.24	18,207.74	28,728.59	34,611.67	36,935.61	0.00	10,528.71	582.67	9731.33
0354-0677	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0354-0678	363,548.22	0.00	0.00	7609.61	0.00	0.00	1196.70	0.00	0.00
0354-0679	283,940.47	256.19	260.10	0.00	0.00	0.00	0.00	0.00	0.00
0355-0644	2904.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0355-0649	68,191.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0355-0650	416,873.03	0.00	0.00	0.00	0.00	0.00	7152.75	0.00	0.00
0355-0651	596,055.84	19,174.09	26,778.44	19,463.05	18,157.42	0.00	12,308.75	3678.14	0.00
0355-0652	649,516.24	14,965.10	5531.40	0.00	0.00	0.00	12,150.89	0.00	0.00
0355-0653	649,516.24	0.00	0.00	0.00	0.00	0.00	26,076.49	0.00	0.00
0355-0654	649,516.24	0.00	0.00	0.00	0.00	0.00	4332.78	672.38	0.00
0355-0655	649,516.24	1776.87	1373.54	1377.74	0.00	0.00	9144.31	0.00	0.00
0355-0656	649,516.24	0.00	0.00	0.00	0.00	0.00	9467.91	0.00	0.00
0355-0657	649,516.24	0.00	0.00	0.00	0.00	0.00	10,369.04	0.00	0.00
0355-0658	649,516.24	3868.95	4237.86	2856.30	0.00	0.00	1638.00	0.00	0.00
0355-0659	649,516.24	22,255.00	24,196.51	34,519.00	15,204.11	0.00	7702.39	0.00	0.00
0355-0660	649,516.24	2741.08	1715.57	1773.01	0.00	0.00	2085.78	0.00	0.00
0355-0661	649,516.24	517.69	0.00	1007.14	0.00	0.00	6005.26	1276.62	0.00
0355-0662	649,516.24	131.18	0.00	2943.95	0.00	0.00	7328.29	413.97	0.00
0355-0663	649,516.24	4393.73	0.00	0.00	0.00	0.00	20,810.26	0.00	0.00
0355-0664	649,516.24	0.00	0.00	0.00	0.00	0.00	4657.13	1055.54	0.00
0355-0665	649,516.24	8350.88	0.00	0.00	0.00	0.00	8700.77	0.00	9483.97
0355-0666	649,516.24	7194.27	0.00	0.00	0.00	0.00	1737.08	0.00	0.00
0355-0667	649,516.24	469.04	0.00	0.00	0.00	0.00	2573.77	0.00	0.00
0355-0668	649,516.24	1094.46	0.00	3718.52	0.00	0.00	272.99	1419.77	0.00
0355-0669	649,516.24	0.00	0.00	0.00	0.00	0.00	4142.15	0.00	0.00
0355-0670	649,516.24	0.00	0.00	0.00	0.00	0.00	273.03	0.00	0.00
0355-0671	649,516.24	0.00	0.00	0.00	0.00	0.00	3266.64	48.35	0.00
0355-0672	649,516.24	4377.45	421.95	437.30	0.00	0.00	495.88	642.25	0.00
0355-0673	649,516.24	2003.58	0.00	0.00	0.00	0.00	272.99	0.00	3204.40
0355-0674	649,516.24	1061.24	0.00	0.00	0.00	0.00	1415.13	229.45	0.00
0355-0675	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0355-0676	481,897.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0355-0677	493,565.53	31,630.46	4738.12	4853.05	0.00	0.00	0.00	1176.79	0.00
0355-0678	37,200.21	5748.01	0.00	0.00	0.00	0.00	0.00	54.89	0.00
0355-0679	90.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0356-0645	278,075.32	0.00	0.00	0.00	0.00	0.00	2832.40	0.00	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0356-0646	274,117.16	0.00	0.00	0.00	0.00	0.00	1092.04	0.00	0.00
0356-0647	520,308.12	0.00	0.00	0.00	0.00	0.00	2183.92	0.00	0.00
0356-0648	649,516.24	7816.25	5297.87	5730.79	11,605.36	0.00	16,463.83	0.00	0.00
0356-0649	605,837.33	0.00	0.00	0.00	0.00	0.00	2457.10	0.00	0.00
0356-0650	649,516.24	0.00	0.00	0.00	0.00	0.00	6694.16	0.00	0.00
0356-0651	649,516.24	0.00	0.00	0.00	0.00	0.00	28,168.22	0.00	0.00
0356-0652	649,516.24	1059.72	219.58	0.00	0.00	0.00	15,782.06	0.00	0.00
0356-0653	649,516.24	15,673.01	5762.18	0.00	0.00	0.00	24,773.57	1148.62	0.00
0356-0654	649,516.24	3232.21	1377.12	0.00	0.00	0.00	77,740.87	617.78	0.00
0356-0655	649,516.24	0.00	0.00	0.00	0.00	0.00	22,696.40	0.00	0.00
0356-0656	649,516.24	0.00	381.72	382.88	0.00	0.00	35,521.72	0.00	0.00
0356-0657	649,516.24	0.00	0.00	414.80	0.00	0.00	8379.18	0.00	0.00
0356-0658	649,516.24	43,024.98	31,765.94	50,912.23	29,586.35	0.00	24,337.70	0.00	0.00
0356-0659	649,516.24	0.00	0.00	9852.27	0.00	0.00	4365.30	0.00	0.00
0356-0660	649,516.24	13,446.97	10,545.19	10,467.34	11,693.34	0.00	4955.54	0.00	0.00
0356-0661	649,516.24	0.00	0.00	0.00	0.00	0.00	545.99	0.00	0.00
0356-0662	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	2315.72	0.00
0356-0663	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0356-0664	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0356-0665	649,516.24	0.00	616.21	2538.29	0.00	0.00	0.00	3192.37	2805.38
0356-0666	649,516.24	0.00	18,115.68	4311.99	0.00	0.00	0.00	0.00	0.00
0356-0667	649,516.24	0.00	0.00	0.00	0.00	0.00	171.00	0.00	0.00
0356-0668	649,516.24	0.00	9174.81	11,608.00	0.00	0.00	818.99	140.99	0.00
0356-0669	649,516.24	0.00	10,893.99	13,676.22	0.00	0.00	0.00	1028.38	0.00
0356-0670	649,516.24	0.00	0.00	11,010.74	0.00	0.00	1346.16	0.00	0.00
0356-0671	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0356-0672	649,516.24	0.00	0.00	0.00	0.00	0.00	56.85	0.00	0.00
0356-0673	649,516.24	648.28	0.00	3143.00	0.00	0.00	1581.02	0.00	0.00
0356-0674	649,516.24	0.00	310.15	5170.86	0.00	0.00	0.00	0.00	0.00
0356-0675	636,637.14	0.00	0.00	3229.87	0.00	0.00	11,057.35	0.00	787.19
0356-0676	260,560.70	0.00	0.00	0.00	0.00	0.00	1975.97	0.00	0.00
0356-0677	6540.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0647	215,397.16	0.00	0.00	0.00	0.00	0.00	19,413.00	0.00	0.00
0357-0648	4759.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0649	562,722.96	0.00	0.00	138.26	0.00	0.00	2221.10	0.00	0.00
0357-0650	618,885.03	0.00	81.35	34.32	0.00	0.00	3783.21	0.00	0.00
0357-0651	649,516.24	0.00	0.00	0.00	0.00	0.00	9409.77	0.00	0.00
0357-0652	649,516.24	0.00	0.00	0.00	0.00	0.00	7509.95	0.00	0.00
0357-0653	649,516.24	8056.07	3540.92	0.00	0.00	0.00	20,608.29	1713.80	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0357-0654	649,516.24	21,903.84	8644.44	3350.57	5327.49	5994.20	14,365.95	482.34	0.00
0357-0655	649,516.24	0.00	0.00	0.00	0.00	0.00	27,828.64	0.00	0.00
0357-0656	649,516.24	128,791.39	121,207.98	121,865.63	126,055.03	172,840.88	100,639.57	848.28	0.00
0357-0657	649,516.24	6302.16	4810.46	4807.49	9942.00	0.00	11,328.09	0.00	0.00
0357-0658	649,516.24	98,520.34	92,710.98	92,188.41	94,886.95	147,672.15	65,415.22	648.07	0.00
0357-0659	649,516.24	0.00	0.00	380.14	0.00	0.00	2995.37	0.00	0.00
0357-0660	649,516.24	15,479.19	44,203.47	43,522.75	43,191.78	0.00	24,508.42	876.56	0.00
0357-0661	649,516.24	3095.92	17,031.20	16,913.87	11,861.99	0.00	538.27	0.00	5745.27
0357-0662	649,516.24	0.00	0.00	0.00	0.00	0.00	3187.15	0.00	0.00
0357-0663	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0664	649,516.24	0.00	46,597.04	45,951.94	50,677.02	0.00	37,953.87	76.31	0.00
0357-0665	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	938.52	0.00
0357-0666	649,516.24	0.00	6611.96	4971.13	5034.83	0.00	8784.54	969.92	0.00
0357-0667	649,516.24	0.00	10,557.44	8545.83	0.00	0.00	0.00	0.00	0.00
0357-0668	649,516.24	0.00	0.00	0.00	0.00	0.00	2547.16	0.00	0.00
0357-0669	649,516.24	0.00	726.49	989.60	0.00	0.00	273.03	271.81	0.00
0357-0670	649,516.24	0.00	0.00	0.00	0.00	0.00	3152.53	0.00	0.00
0357-0671	649,516.24	1333.11	0.00	0.00	0.00	0.00	849.92	0.00	0.00
0357-0672	649,516.24	0.00	0.00	0.00	0.00	0.00	780.35	0.00	0.00
0357-0673	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3574.03
0357-0674	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0675	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0676	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0677	451,445.24	0.00	3400.04	509.30	0.00	0.00	0.00	0.00	0.00
0357-0678	560,957.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0680	508,254.67	0.00	0.00	0.00	0.00	0.00	0.00	1100.45	0.00
0357-0681	34.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0357-0682	495,873.26	403.71	18,108.06	0.00	0.00	0.00	12,403.48	140.57	0.00
0357-0684	146,990.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0644	120,679.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0646	560,160.50	11,194.37	408.16	330.07	0.00	0.00	6326.04	243.40	0.00
0358-0647	46,646.99	0.00	0.00	0.00	0.00	0.00	255.26	0.00	0.00
0358-0648	649,516.24	8460.65	0.00	0.00	0.00	0.00	5827.25	716.83	1548.99
0358-0649	285,773.51	4807.71	4043.41	8726.87	0.00	0.00	6216.75	0.00	0.00
0358-0650	649,516.24	710.94	614.28	0.00	0.00	0.00	4357.58	0.00	0.00
0358-0651	649,516.24	14,396.62	10,976.98	15,023.04	0.00	0.00	6887.09	0.00	0.00
0358-0652	649,516.24	0.00	0.00	0.00	0.00	0.00	27,981.69	0.00	0.00
0358-0653	649,516.24	16,825.12	5126.61	0.00	0.00	0.00	6881.26	959.03	12,077.20

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0358-0654	649,516.24	12,821.20	2372.17	0.00	0.00	0.00	11,125.26	142.62	0.00
0358-0655	649,516.24	4839.74	3791.18	4089.19	4931.87	9982.79	21,764.62	0.00	0.00
0358-0656	649,516.24	0.00	0.00	0.00	0.00	0.00	13,843.78	0.00	0.00
0358-0657	649,516.24	47,846.69	45,572.35	45,947.79	46,670.57	68,199.70	34,875.96	43.28	0.00
0358-0658	649,516.24	0.00	0.00	0.00	0.00	0.00	811.35	0.00	0.00
0358-0659	649,516.24	20,445.62	17,549.22	15,285.95	17,662.78	28,443.71	11,772.17	592.16	0.00
0358-0660	649,516.24	0.00	358.94	3548.32	0.00	0.00	817.36	0.00	0.00
0358-0661	649,516.24	0.00	0.00	0.00	0.00	0.00	5196.89	0.00	0.00
0358-0662	649,516.24	17,204.74	4977.12	4856.87	0.00	0.00	10,700.48	1372.70	0.00
0358-0663	649,516.24	0.00	15,236.51	15,234.96	17,286.29	0.00	13,916.85	234.00	0.00
0358-0664	649,516.24	0.00	0.00	0.00	0.00	0.00	5699.79	0.00	0.00
0358-0665	649,516.24	0.00	583.57	508.42	230.55	0.00	185.68	720.08	0.00
0358-0666	649,516.24	0.00	9880.02	0.00	0.00	0.00	366.85	0.00	0.00
0358-0667	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0668	648,007.80	0.00	0.00	0.00	0.00	0.00	273.11	0.00	0.00
0358-0669	649,516.24	0.00	0.00	0.00	0.00	0.00	1055.56	0.00	0.00
0358-0670	649,516.24	0.00	3749.55	293.37	0.00	0.00	0.00	0.00	0.00
0358-0671	649,516.24	0.00	32.75	24.33	0.00	0.00	391.21	1170.44	0.00
0358-0672	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	596.93	0.00
0358-0673	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0674	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0675	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0676	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0677	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0678	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	2183.25	5072.90
0358-0679	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	641.43	0.00
0358-0680	649,516.24	0.00	1632.18	1637.95	2848.29	0.00	0.00	0.00	0.00
0358-0681	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4561.96
0358-0682	649,516.24	0.00	10,829.23	10,275.04	11,212.10	0.00	272.98	0.00	0.00
0358-0683	649,516.24	7783.58	22,675.69	0.00	20,217.26	0.00	9559.71	1979.06	0.00
0358-0684	589,012.97	10,538.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0685	188,614.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0358-0686	14,806.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0645	225,126.91	0.00	0.00	0.00	0.00	0.00	4579.00	0.00	0.00
0359-0647	370,159.03	7036.61	0.00	0.00	19.72	0.00	1102.84	0.00	0.00
0359-0648	129,804.80	0.00	0.00	0.00	0.00	0.00	819.11	0.00	0.00
0359-0649	596,569.78	5665.01	0.00	0.00	0.00	0.00	9406.59	586.47	0.00
0359-0650	649,516.24	265.09	0.39	346.98	0.00	0.00	6541.28	0.00	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0359-0651	649,516.24	2242.12	1445.70	2592.97	0.00	0.00	7617.77	0.00	0.00
0359-0652	649,516.24	15,718.10	6623.44	0.00	0.00	0.00	10,949.04	4404.38	0.00
0359-0653	649,516.24	17,394.43	4007.97	0.00	0.00	0.00	12,303.77	0.00	0.00
0359-0654	649,516.24	0.00	0.00	8126.33	0.00	0.00	13,762.61	0.00	0.00
0359-0655	649,516.24	0.00	30,110.41	30,287.36	32,536.72	0.00	35,055.94	0.00	0.00
0359-0656	649,516.24	0.00	0.00	0.00	0.00	0.00	7821.21	0.00	0.00
0359-0657	649,516.24	0.00	7209.87	15,116.74	4366.99	0.00	7467.69	0.00	0.00
0359-0658	649,516.24	0.00	0.00	0.00	0.00	0.00	11,201.91	0.00	0.00
0359-0659	649,516.24	0.00	4457.32	756.76	0.00	0.00	3883.87	0.00	0.00
0359-0660	649,516.24	0.00	25,416.14	25,419.45	25,002.94	0.00	22,823.91	0.00	0.00
0359-0661	649,516.24	5309.60	0.00	11,558.25	0.00	0.00	546.08	1085.70	7223.22
0359-0662	649,516.24	37,781.97	25,056.00	23,190.55	25,493.08	0.00	15,200.34	722.20	0.00
0359-0663	649,516.24	0.00	0.00	0.00	0.00	0.00	1928.82	0.00	0.00
0359-0664	649,516.24	48.79	0.00	0.00	0.00	0.00	8669.11	1693.95	0.00
0359-0665	649,516.24	0.00	10,369.64	14,642.23	0.00	0.00	538.28	1383.83	4561.72
0359-0666	649,454.40	0.00	0.00	0.00	0.00	0.00	273.00	0.00	0.00
0359-0667	549,531.87	87.66	0.00	0.00	0.00	0.00	0.00	1482.06	0.00
0359-0668	327,119.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0669	588,458.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0670	649,516.24	0.00	55,003.32	54,078.07	58,840.66	0.00	46,393.36	684.21	0.00
0359-0671	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	1753.82	3462.14
0359-0672	649,516.24	0.00	4655.06	5872.39	558.76	0.00	343.24	0.00	0.00
0359-0673	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0674	649,516.24	0.00	151.83	10,385.22	14,463.39	0.00	3543.35	0.00	0.00
0359-0675	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0676	649,516.24	0.00	0.00	4463.01	2410.62	0.00	2510.84	831.75	0.00
0359-0677	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0678	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0679	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0680	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0681	649,516.24	0.00	0.00	200.84	0.00	0.00	0.00	0.00	0.00
0359-0682	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0683	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0684	406,809.47	0.00	247.04	197.01	0.00	0.00	0.00	0.00	0.00
0359-0685	606,551.22	0.00	518.91	760.41	0.00	0.00	0.00	0.00	0.00
0359-0686	60,431.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0687	218,919.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0359-0688	733.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0648	7.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A1. *Cont.*

Hexagon Number	Hexagon Area [sq. m]	Water Area by EGiB [sq. m]	Water Area by BDOT [sq. m]	Water Area by MPHP [sq. m]	Water Area by UA [sq. m]	Water Area by CLC [sq. m]	Water Area by NDWI [sq. m]	River Length by BDOT [m]	River Length by MPHP [m]
0360-0649	579,073.24	58,925.27	27,786.62	31,643.89	22,239.77	30,678.10	14,077.65	0.00	0.00
0360-0650	372,832.40	148,803.50	110,639.64	85,081.64	96,811.87	160,660.16	48,063.56	0.00	0.00
0360-0651	649,516.24	5059.28	0.00	0.00	76.69	4789.17	0.00	0.00	0.00
0360-0652	649,516.24	328,395.34	306,634.88	300,341.02	309,097.03	307,386.41	256,677.83	0.00	0.00
0360-0653	649,516.24	10,437.89	5311.34	0.00	0.00	0.00	14,010.29	0.00	0.00
0360-0654	649,516.24	3040.87	812.81	0.00	0.00	0.00	18,359.07	0.00	0.00
0360-0655	649,516.24	0.00	0.00	0.00	0.00	0.00	13,829.43	0.00	0.00
0360-0656	610,583.42	47,791.25	34,793.47	35,900.64	0.00	0.00	7743.34	0.00	0.00
0360-0657	649,516.24	21,234.44	17,926.73	17,667.62	16,532.12	0.00	8843.25	0.00	0.00
0360-0658	184,175.67	10,498.97	2845.66	3779.55	0.00	0.00	0.00	807.21	0.00
0360-0659	649,516.24	10,474.58	12,293.26	12,299.63	13,548.83	0.00	9297.58	965.08	0.00
0360-0660	178,724.93	4487.07	0.00	0.00	0.00	0.00	0.00	251.89	251.96
0360-0661	648,369.08	19,872.17	3726.97	0.00	0.00	0.00	819.01	543.64	0.00
0360-0662	31,658.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0663	548,891.78	0.00	0.00	659.81	0.00	0.00	448.31	0.00	0.00
0360-0665	376,101.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0667	92,506.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0669	364,043.24	0.00	3860.17	0.00	0.00	0.00	1573.49	443.39	0.00
0360-0671	330,804.95	0.00	27,686.68	28,619.69	29,997.43	0.00	18,159.33	11.66	0.00
0360-0672	384.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0673	629,459.95	0.00	0.00	550.05	0.00	0.00	0.00	474.14	0.00
0360-0674	178,269.68	0.00	0.00	0.00	0.00	0.00	1050.96	0.00	0.00
0360-0675	649,516.24	0.00	7091.61	19,809.78	0.00	0.00	15,040.81	644.45	0.00
0360-0676	388,241.33	0.00	2255.37	0.00	0.00	0.00	74.47	0.00	1281.71
0360-0677	649,516.24	0.00	283.75	300.78	0.00	0.00	0.00	0.00	0.00
0360-0678	527,454.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0679	649,516.24	0.00	108.04	816.91	0.00	0.00	0.00	0.00	0.00
0360-0680	344,555.94	0.00	110.07	0.00	0.00	0.00	0.00	0.00	0.00
0360-0681	649,516.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0682	423,139.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0683	366,949.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0360-0684	71,040.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0361-0651	275,294.78	116,726.47	108,778.88	105,214.53	108,193.01	147,204.74	71,452.07	0.00	0.00
0361-0652	63,675.69	37,370.64	34,809.88	33,335.08	38,526.52	43,847.93	27,436.97	0.00	0.00
0361-0653	584,230.64	316,697.09	299,612.57	288,010.92	311,705.80	333,254.41	232,704.03	0.00	0.00
0361-0655	315,281.30	0.00	0.00	0.00	0.00	0.00	273.01	0.00	0.00
0361-0657	7165.56	0.00	0.00	0.00	0.00	0.00	74.57	0.00	0.00
0361-0679	39,207.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: own study.

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