The challenges of reconstructing the historic urban landscape of Lublin in the Lublin Union period (1569) in an interactive map

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Zarys treści: *Lublin w okresie Unii Lubelskiej (1569)* to tytuł projektu, którego ideą było stworzenie portalu tematycznego (https://teatrnn.pl/unia-lubelska/) mającego wprowadzić użytkownika w świat XVI-wiecznego Lublina. Kluczowym zadaniem było opracowanie mapy interaktywnej (WEB-GIS), wykorzystującej dane przestrzenne oraz badania nieinwazyjne. Podstawą retrogresji 450 lat przemian były głównie niekartograficzne źródła informacji (źródła pisane, dokumentacja konserwatorska, ryciny). Zaangażowanie zespołu interdyscyplinarnego i nowoczesnych narzędzi zaowocowało opracowaniem modelu, który z jednej strony jest zgodny z najnowszym stanem wiedzy, a z drugiej – w poglądowej formie przybliża naukowe ustalenia niewykwalifikowanemu odbiorcy.

Abstract: Lublin in the Union of Lublin Period (1569) is a 2019 interdisciplinary research project with the idea to develop an internet portal (https://teatrnn.pl/unia-lubelska/), which would introduce the user to the world of 16th-century Lublin. A key task was to create an interactive map (WEB-GIS) using spatial data and non-invasive research. The basis for the retrogression of 450 years of transformation was mainly non-cartographic sources of information (written sources, conservation documentation, engravings). The involvement of an interdisciplinary team and modern tools resulted in a model that, on the one hand, is state-of-the-art and, on the other, brings scientific findings closer to a non-specialist audience in an illustrative form.

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Słowa kluczowe: Lublin, miasto, układ przestrzenny, Unia Lubelska 1569, GIS historyczny, mapa interaktywna, retrogresja

Keywords: Lublin, city, town, spatial layout, 1569 Union of Lublin, historical GIS, interactive map, retrogression

Introduction

The year 2019 marked the 450th jubilee of a watershed moment in Poland's history – the signing of the Union of Lublin. This Polish-Lithuanian Union in Lublin was not only without precedence. For sixteenth-century Europe, it carried significance comparable to that of the modern-day establishment of the European Union.[1] Celebrations of the 450th Union of Lublin anniversary encompassed numerous cultural and educational events to promote Lublin's Jagiellonian history and cultural heritage.

In cooperation with Lublin academic experts, 'Grodzka Gate – NN Theatre Centre' in Lublin developed a multimedia website about Lublin during the Lublin Union (www.teatrnn.pl/unia-lubelska). A key portal element is an interactive map, which constitutes a cartographic reconstruction of Lublin's urban layout in the sixteenth century. Combining current knowledge about Lublin's urban landscape in the explored period, the map serves as a universal cognitive model. The API enables juxtaposing historic and contemporary spaces and comparing the evolution and location of surviving architectural and urban heritage remnants. Applying a deep map interface opens for enriching the map with narratives about locations, individuals, events, and the sources used. Interactive references to digital libraries (dLibra), audio/video recordings (YouTube) and virtual 3D models (Sketchfab) render our message more illustrative, attractive and practical for mass users. Other team publications have discussed the editing and technical assumptions behind the philosophy of the Historical Geoportal of Lublin (Lublin HGIS) and interactive mapping.[2] In this article, the authors emphasise the methodological issues connected with the cartographic reconstruction of specific elements of the town's sixteenth-century topography.

1. Methodology

Lublin in the Union of Lublin Period (1569) was an interdisciplinary project from many research standpoints: archaeology, architecture, historical geography, urban geography, history, art history, cartography, and geomatics. Owing to the absence of original cartographic sources that could provide the details of Lublin's sixteenth-century urban landscape, the main research problem was creating a map with cartographic reconstruction methods. An analysis of diverse source materials formed the basis for the cartographic recreation of urban space. The sources examined included written sources, cartographic and iconographic materials, historical and architectural documentation, archaeological documents, direct research, stock taking, and field measuring.

From a methodological perspective, historical geography offers the broadest basis for employing such a heterogeneous data set. The retrogressive (cartographic regression) method, introduced by German historians in the second half of the

[1] I. Hofman (ed.), *Unia Lubelska – Unia Europejska* (Lublin: Wydawnictwo UMCS, 2011). An extensive overview of scientific publications on the Lublin Union is available at www.teatrnn.pl/leksykon/artykuly/unia-lubelska-bibliografia.

[2] Cf. J. Kuna, Ł. Kowalski, 'Exploring a non-existent city via historical GIS system by the example of the Jewish district 'Podzamcze' in Lublin (Poland)', *Journal of Cultural Heritage*, vol. 46 (2020), pp. 328–32; J. Kuna et al., 'Interactive HGIS Platform Union of Lublin (1569): A geomatic solution for discovering the Jagiellonian heritage of the city', *Journal of Cultural Heritage*, vol. 53 (2022), pp. 47–71.

nineteenth century, is particularly suitable to this end. Stanisław Arnold advanced this method in Poland in the 1920s. To this day, it remains the cornerstone of the methodological repertoire of Polish historical geography.[3] As modern computer technologies, geographical information systems (GIS), and websites were used for data collection, processing and publishing, this paper ought to be attributed to the modern fields of the geomatic research-supporting method (geomatic method)[4] and the historical geographic information system (Historical GIS).[5]

Concerning the most recent global trends, the authors adopted a broad understanding of historical GIS in this case. Consequently, it is perceived not only as a tool, i.e. a GIS desktop software, for spatial and temporal data collection and analysis. Historical GIS is predominantly understood as an interactive networking platform (website with map interface, geoportal) which allows for organising data in hierarchical structures, creating relational links within and between different categories of objects, and embedding multimedia (images, audio and video recordings, 3D models).[6] As outlined above, Historical GIS is a publication platform which engages deep mapping to design a multi-dimensional spatial narrative addressed to mass recipients.[7]

2. The current state of research

Preparations for map reconstruction consisted of selecting a preliminary list of publications which could constitute the reconstruction base.[8] Such sources on Lublin fall within two groups: valuable yet general monographs and particular, detailed papers on individual sixteenth-century buildings. The former category comprises *Lublin. Rozwój przestrzenny i funkcjonalny od średniowiecza do współczesności* [Lublin. Spatial and Functional Development from the Middle Ages to the Present],[9] a monograph that recreates both the town's administrative borders as of the late fifteenth century and its functional and spatial layout, broken down into blocks of buildings, roadways, and the hydrographic grid of the time. The interdisciplinary collective publication is titled *Lublin. 700 lat dziejów miasta* [Lublin. 700 Years of Town History], *Plany i widoki Lublina XVII–XXI wiek* [Plans and Views of Lublin. 17th–21st Centuries],[10] and the monograph *Lublin: Przeobrażenia urbanistyczne 1815–1939* [Lublin: Urban Transformations, 1815–1939][11] present a general overview of the sixteenth-century urban centre and reconstruct the town plans of Lublin in the times of the Union of Lublin. Regrettably, the enclosed maps were highly general and failed to reflect the division of urban space into parcels. The interdisciplinary

[3] S. Arnold, 'Geografja historyczna, jej zadania i metody', *Przegląd Historyczny*, vol. 28, no. 1 (1929), p. 115. Cf. H. Rutkowski, 'Metoda retrogresji w geografii historycznej Polski (wybrane zagadnienia)', *Studia Geohistorica*, no. 7 (2020), pp. 146–62.

[4] Z. Kozieł, 'Concerning the need for development of the geomatic research method', *Geodezja i Kartografia*, vol. 46, no. 3 (1997), pp. 207–14.

[5] I.N. Gregory, *A Place in History: A Guide to Using GIS in Historical Research*, 2nd edn (Belfast: Arts and Humanities Data Service/Oxbow Books, 2003), the first edition available online at: http://hds.essex.ac.uk/g2gp/gis/index.asp (accessed on 8 Jan. 2025); B. Szady, 'Zastosowanie systemów informacji geograficznej w geografii historycznej', *Polski Przegląd Kartograficzny*, vol. 40, no. 3 (2008), pp. 279–83; id., 'Geografia historyczna w Polsce – rozwój i perspektywy', *Studia Geohistorica*, no. 1 (2013), pp. 19–38.

[6] T.M. Harris, 'Deep Geography – Deep Mapping', in *Deep Maps and Spatial Narratives*, ed. D.J. Bodenhamer, J. Corrigan, and T.M. Harris (Bloomington–Indianapolis: Indiana University Press, 2015), pp. 28–53.

[7] *The Spatial Humanities: GIS and the Future of Humanities Scholarship*, ed. D.J. Bodenhamer, J. Corrigan, and T.M. Harris (Bloomington–Indianapolis: Indiana University Press, 2010).

[8] The list of scientific publications used is available at www.teatrnn.pl/unia-lubelska/literatura/.

[9] D. Kociuba, *Lublin. Rozwój przestrzenny i funkcjonalny od średniowiecza do współczesności* (Toruń: Wydawnictwo Adam Marszałek, 2011).

[10] *Lublin. 700 lat dziejów miasta*, ed. G. Figiel, R. Szczygieł, and W. Śladkowski (Lublin: Wojewódzka Biblioteka Publiczna im. Hieronima Łopacińskiego, 2017); *Plany i widoki Lublina XVII–XXI wiek*, ed. M. Harasimiuk, D. Kociuba, P. Dymmel (Lublin: PTTK, 2007).

[11] N. Przesmycka, *Lublin: przeobrażenia urbanistyczne 1815–1939* (Lublin: Wydawnictwo Politechniki Lubelskiej, 2012).

scientific bulletins of *Lublin. Historia dzielnic. W 700. rocznicę lokacji miasta* [Lublin. History of Districts. On the 700th Anniversary of the Town Charter][12] contributed notably to recreating the space beyond town walls. Unfortunately, the entire series approached the sixteenth century in relatively general terms. *Mury miejskie Lublina* [The Town Walls of Lublin][13] is an interesting title synthesising spatial issues. Nevertheless, it should be stressed that it was published only after the project discussed here had been completed. Both teams drew many convergent conclusions on town fortifications in parallel. The Lublin volume of the *Zabytki architektury i budownictwa w Polsce* [Architectural and Construction Artefacts in Poland] series is an example of a detailed source.[14] The volume offers a thorough list of historic buildings with dates but does not discern between different periods or provide a cartographic synthesis. Further in the article, the authors describe the partial sources and methods used to develop a cartographic model of sixteenth-century Lublin.

a) Historical queries

Reconstructing the map of Lublin during the Lublin Union period was based principally on written sources (Table 1). The following proved to be invaluable collections of data on the layout of Lublin's urban structures in the sixteenth century: *Inspection of Lubelskie Voivodeship of 1565*[15], *Inspections of Lublin Town of 1564 and 1570* (Fig. 1) and *schoss* (tax) registers of 1524 and 1573, which are available at the State Archives in Lublin.[16] These documents contain information about significant buildings, including their owners' details, street names and surrounding venues. Identifying building layout and the boundaries of the parish and monastic estates necessitated a query of church sources: Acts of the Lublin Consistory (1630–1633), Acts of Visitation to Lublin Archdiocese of 1595 and 1603[17] – available at the Lublin Archdiocesan Archives and the Archives of the Metropolitan Curia in Cracow. The query covered all significant archival collections on Lublin of the sixteenth and seventeenth centuries. This query was the first to analyse

[12] *Lublin. Historia dzielnic. W 700. rocznicę lokacji miasta*, ed. J. Chachaj, H. Mącik, and D. Szulc, Series: Historia Micra – Historia Magna, vol. 4 (Lublin: Lubelskie Towarzystwo Genealogiczne, 2017).

[13] J. Teodorowicz-Czerepińska, G. Michalska, *Mury miejskie Lublina* (Lublin: Urząd Miasta Lublin, 2021).

[14] E. Bortkiewicz, 'Miasto Lublin', in *Zabytki architektury i budownictwa w Polsce*, vol. 22: *Województwo lubelskie* (Warszawa: Ośrodek Dokumentacji Zabytków, 1995), pp. 211–65.

[15] *Lustracja województwa lubelskiego 1565*, ed. A. Wyczański (Wrocław–Warszawa: PAN Instytut Historii, 1959).

[16] Archiwum Państwowe w Lublinie [States Archives in Lublin] (hereinafter: APL), Akta miasta Lublina [Acts of the Town of Lublin] (hereinafter: AmL), Rejestry dochodów, wydatków, podatkowe [Registers of income, expenses, and taxes], Rejestr podatków, kontrybucji zwanych szos [zbieranych] podczas interregnum autorytetu generalnej konfederacji warszawskiej i partykularnej lubelskiej, wedle konstytucji sejmu generalnego lubelskiego z roku 1569 [Register of taxes, shoss contributions [collected] during the interregnum by authority of the General Warsaw Confederation and the Local Lublin Confederation, in compliance with the Constitution of the General Sejm of Lublin of 1596], ref. no. 267; APL, AmL, Lustracje Miasta Lublina i Województwa Lubelskiego [Inspection of the Town of Lublin and Lublin Voivodeship], Lustracja miasta Lublina z 1564 roku [Inspection of the Town of Lublin of 1564], ref. no. 309; ibid., Lustracja miasta Lublina z 1570 roku [Inspection of the Town of Lublin of 1570], ref. no. 310; W. Patronowicz, 'Socjotopografia późnośredniowiecznego Lublina w świetle lubelskiego rejestru podatkowego z 1524 roku', MA thesis, Institute of History, University of Warsaw, 2012, typescript at the archive of 'Grodzka Gate – NN Theatre Centre' in Lublin.

[17] Archiwum Archidiecezjalne Lubelskie [Lublin Archdiocesan Archives], *Akta wizytacji archidiakonatu lubelskiego z 1603 roku* [Acts of Visitation of the Lublin Archdiocese of 1603] *(Visitatio ecclesiarum et totius cleri in archidiaconatu Lublinensi Illustrissimi et Reverendissimi Domini D. Bernardi Maczieiowski Dei et Apostolicae Sedis Gratia Episcopi Cracoviensi Ducis Severiensis facta et conscripta per Deputatum Reverendum Thomasium Iossicium Canonicum Vislicensem Officialem Lublinensem in Anno MDCIII)*, ref. no. Rep. 60A 96; ibid., *Akta Konsystorza Lubelskiego* (*Acta Consistorii Lublinensis 1630–1633*), ref. no. Rep 60A 22 (1630–1633); Archiwum Krakowskiej Kapituły Katedralnej [Archives of Cracow Cathedral Chapter], deposit at the Metropolitan Curia Archives in Cracow, *Akta wizytacji archidiakonatu lubelskiego z 1595 roku* [Acts of Visitation of the Lublin Archdiocese of 1595] *(Acta visitationis ecclesiarum in Archidiaconatu Lublinensis ubilibet consistentes. Per Reuerendum Dominum Georgium Zamoyski de Zamoście archidiaconum Lublinensem et canonicum Cracoviensem gesta et obseruata sequuntur sub anno Domini MD.XC Quinto)*, ref. no. AV Cap 3.

Table 1. Archival descriptive sources used for the reconstruction of the space of 16th-century Lublin

No.	Date	Original title	Author, authors	Language	Access type	No. of mentioned object	Information used
1.	1565	Lustracja województwa lubelskiego	Marcin Falęcki h. Leszczyc, Paweł Działyński h. Ogończyk, Sebastian Wielogłowski h. Starykoń	Polish and Latin	Printed edition A. Wyczański, *Lustracja województwa lubelskiego 1565* (Wrocław–Warszawa: PAN Instytut Historii, 1959)	53	Describes all royal lands in Lubelskie Voivodeship, the information includes, among others, property owners or tenants, approximate location of buildings, functions of buildings, street names and physiographic objects
2.	1570	Lustracja miasta Lublina	unknown	Polish and Latin	Manuscript in State Archives in Lublin (APL): Zespół: 35/22/0 Akta miasta Lublina, Seria: 2.7 Lustracje Miasta Lublina i Województwa Lubelskiego, ref. no. 310	21	Property owners, approximate location of buildings, functions of buildings, street names and physiographic objects
3.	1573	Akta miasta Lublina, księga rachunkowa – dochody i wydatki: Spis podatkowy	Unknown	Polish and Latin	Online scans, microfilm, original manuscript in State Archives in Lublin (APL), Zespół: 35/22/0 Akta miasta Lublina, Seria: 2.5.1 Rejestry Dochodów, Wydatków, Podatkowe, ref. no. 267 https://szukajwarchiwach.pl/35/22/0/2.5.1/267/str/1/21/15/dwXodkVd2q0pPyf1TaoLg/#tabJednostka	443	Property owners, approximate location of buildings, functions of buildings, tax level, street names and physiographic objects
4.	1595	Akta wizytacji kanonicznej archidiakonatu lubelskiego	Jerzy Zamoyski, Lublin archdiacon	Latin	Manuscript in the Archives of the Cracow Cathedral Chapter (deposit in the Archives of the Metropolitan Curia in Cracow)	10	Visitation files contain a description of churches and their surroundings, as well as parts of the clergy's property in the Lublin archdiocese, among others, property owners, approximate location of buildings, cemeteries, gardens, land, building functions, street names and physiographic objects
5.	1603	Akta wizytacji kanonicznej archidiakonatu lubelskiego	Tomasz Josicki, Lublin's official	Latin	Manuscript in the Lublin Archdiocesan Archives	10	Visitation files contain a description of churches and their surroundings, as well as parts of the clergy's property in the Lublin archdiocese, among others, property owners, approximate location of buildings, cemeteries, gardens, land, building functions, street names and physiographic objects
6.	1633	Akta konsystorza lubelskiego	Several witnesses	Polish	Manuscript in the Lublin Archdiocesan Archives	20	Testimonies relating to land located in the northern part of the city limits. Area north of the Czechówka River, including property owners, approximate location of land

Compiled by J. Chachaj & J. Jeremicz (2019).

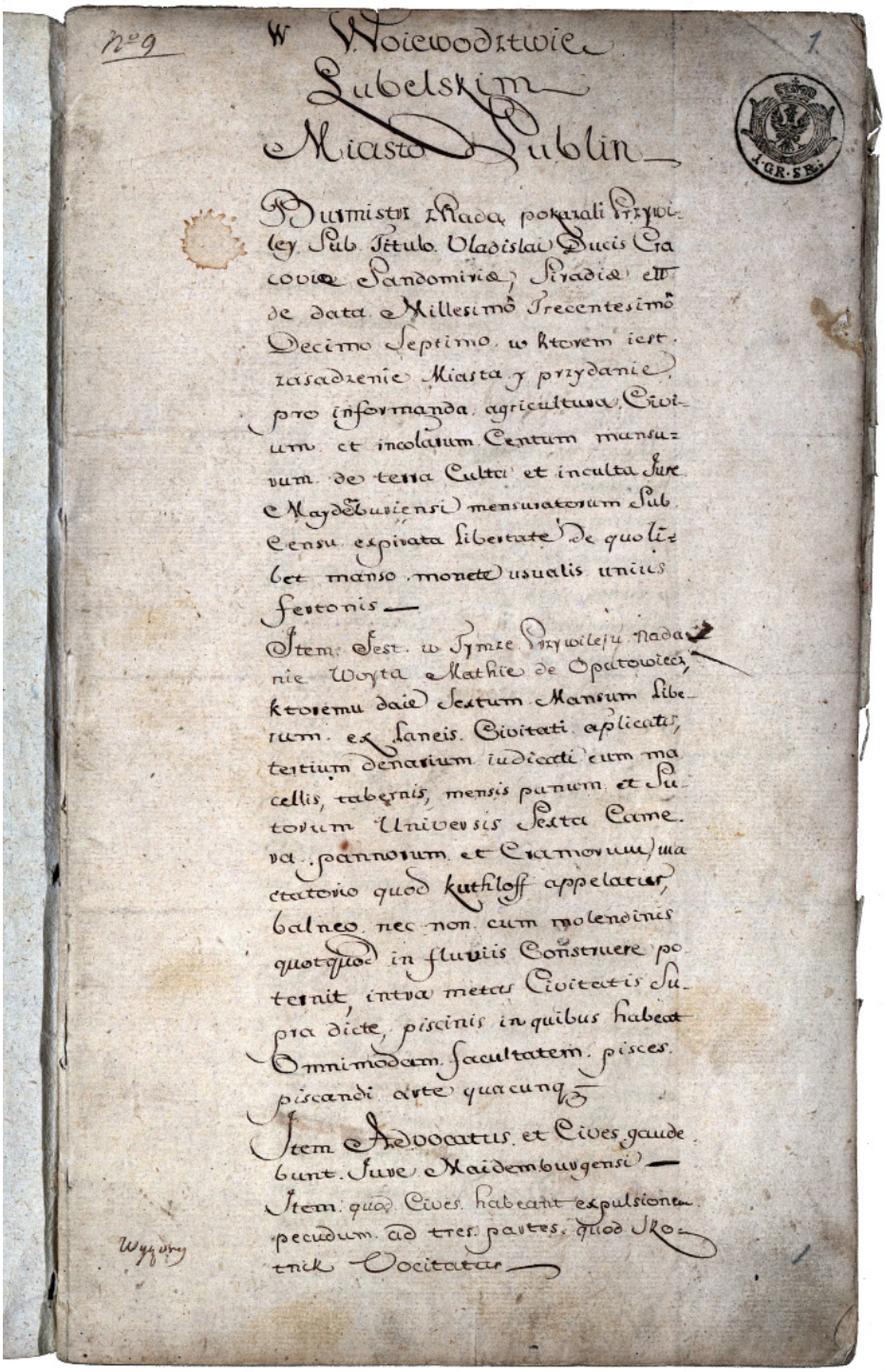

Fig. 1. Inspection of Lubelskie Voivodeship of 1570; States Archives in Lublin, Acts of the Town of Lublin, ref. no. 35/22/0/2.7/310, p. 1

many resources for spatial information. It is worth noting that structures characteristic of the Middle Ages were prominent in early sixteenth-century Lublin. Parcel distribution was, to a large extent, aligned with the 1317 foundation privilege. The town was surrounded by defensive walls erected by King Casimir III the Great's order in the second half of the fourteenth century. The Great Royal Pond also dates back to the fourteenth century. This vast body of water was located east of Old Town Hill. Apart from serving as a defensive structure, the water reservoir also had an important economic purpose. Its role was connected with water mills, whose location and activity are described in the sixteenth- and seventeenth-century inspections mentioned above. In the sixteenth century, Lublin received privileges to establish an urban water supply system, a workshop for separating beeswax from honeycombs, a workshop for melting beeswax, a workshop for bleaching fabrics, and a paper mill.[18]

b) Archaeological and architectural documentation

The analysis of available sixteenth-century sources about Lublin demonstrated that detailed and relatively recent data on Lublin's historical artefacts were indispensable to map reconstruction (Table 2). Consequently, the authors submitted a request to the Lublin Voivodeship Conservator of Historical Monuments for granting access to the collection of conservation documents. Apart from the historical query, our team searched for information on archaeological and architectural research that would enable us to determine whether specific structures of Lublin date back to the sixteenth century. The query at the archives of the Voivodeship Office for Historic Monument Protection (WUOZ) helped acquire data on findings in the Centre and the Old Town.[19] WUOZ documentation was supplemented with individual queries at the Archdiocese and State Archives.

Sixteenth-century archaeological sources played a twofold role in recreating Lublin's urban landscape. On the one hand, they contributed to confirming and clarifying the information found in historical sources. On the other hand, archaeological sources completed the information missing in sixteenth-century historical records,[20] which was particularly important for areas beyond town walls. Archaeological research allowed for the development of a database of reference points, which laid the groundwork for further cartographic materials. The reference points contain documented relations between the layers accumulated over successive stages of urban development. These points frequently denote the relics of immovables (houses and farm buildings) and movable items (everyday use). Analysing the amassed data enables an approximate reconstruction of the settlement area.[21]

We collected information about archaeological research results based on WUOZ excavation documentation and monographs. Both immovable and movable sources constituted the basis for archaeological inference. The former encompassed excavated relics of basements, house foundations, remnants of fortifications (Fig. 2), roadways, sewers, fragments of water supply systems and their features, as well as household installations such as stoves. Immovable historic monuments enabled settlement types to be determined

[18] G. Jakimińska, 'Złoty wiek Lublina', in *Lublin. 700 lat*, p. 75.

[19] *Kościoły i klasztory Lublina w świetle badań archeologicznych*, ed. E. Banasiewicz-Szykuła (Lublin: Wojewódzki Urząd Ochrony Zabytków, 2012); *Zamki Lubelszczyzny w źródłach archeologicznych*, ed. ead. (Lublin: Wojewódzki Urząd Ochrony Zabytków, 2015); *Fortyfikacje Lubelszczyzny. Badania archeologiczne*, ed. ead. (Lublin: Wojewódzki Urząd Ochrony Zabytków, 2017).

[20] A. Rozwałka, 'Archeologia w mieście, miasto w archeologii. Wybrane zagadnienia badań archeologicznych w miastach historycznych', *Analecta Archaeologica Ressoviensia*, vol. 7 (2012), p. 24.

[21] Ibid., pp. 22–23.

Table 2. Non-invasive research used for the reconstruction of the space of 16th-century Lublin

No.	Object	Address (modern)	Research technique	Scope of research	Previous state of research	Added value	Information used
1.	The Bernardine complex of St Paul's Church	Bernardyńska Street 5	GPR	The interior of St Paul's Church, 80% of the church monastery area The surrounding area	At least 6 reconstruction phases have been determined from the end of the 15th century. >50% of the 16th-century substance has been preserved. Archaeological research to date (supervision) in the church's surroundings has indicated the possibility of a cemetery	The geo-radar and architectural surveys carried out are currently the most advanced form of object recognition. The location of the non-existent chapels on the north side, the location of the 'House under the Eagle' building and the inaccessible cellars under almost all the monastery rooms have been determined	Chronological stratification and outline of the range of St Paul's Church for the 16th century. The portal also uses a compilation of documentation from the cemetery's archaeological supervision
2.	St Stanislaus Church (Dominican)	Złota Street 9	GPR, thermography	The interior of the church	At least 6 conversion phases have been defined. >50% of 16th-century substances have been preserved. Until the non-invasive prospectus, such detailed data about the crypts were not available	A thorough stocktaking of the church was carried out, several dozen crypts from different periods were identified, the findings were confirmed during subsequent research and renovation works. Archaeological research in 2017 verified their number, distribution and parameters – there were more of them than according to the GPR	The non-invasive inventory and research allowed to indicate the architectural transformation of the church. The location of the Dominican tower from the 14th century was confirmed. The layout of the church during the Lublin Union period (similar to the shape of the present presbytery and the main nave with the sides) was established. Non-invasive tests were confirmed by empirical studies
3.	St Nicholas Church on Czwartek Hill	Ks. Michał Słowikowski Street 1	GPR	The interior of the church 50% of the surrounding area	At least 10 conversion phases starting from the 15th century have been determined. >50% of 16th-century substances have been preserved. In the field of archaeology, general concepts for the creation and development of the sacred building and the Czwartek Hill settlement were developed	Archaeological discoveries made it possible to verify the thickness of the burial levels of the church cemetery and the structural elements of the sacred building, located below the modern surface of the area. Thanks to non-invasive research, 4 inaccessible crypts and a number of anomalies were found under the church floor, the layout of the terrain and the shape of the hill on which the church was built were determined outside	The original morphology of Czwartek Hill, the layout of the church and the layout of the settlement Czwartek, which in the 16th century was the northern suburb of Lublin, were opened
4.	Holy Trinity Chapel in Lublin Castle	Zamkowa Street 9	GPR	The interior of the chapel	The Holy Trinity Chapel was the subject of various research: archaeological, architectural and historical. The object has extensive descriptive documentation, but so far no transformation phases have been defined	The archaeological recognition of the interior of the chapel is marginal, and apart from indicating the presence of a 'crypt' it did not contribute much. In the tangential space – relations with the Casimir Wall were established and the simultaneous creation of the foundation party was indicated. Thanks to non-invasive research, the location of two inaccessible vaulted rooms inside the building was determined	The external outline of the chapel during the 16th century and the course of the vast majority of the Casimir castle wall (14th century) were confirmed, and the common chronology of the chapel and the castle wall was proved. An attempt was made to reconstruct the development of the Castle Hill area and the places of future research were indicated

5.	The area in front of the main entrance to the Lublin Museum in Lublin Castle	Zamkowa Street 9	GPR	Parcel no. 41, 2200 m^2	The most important source so far is the archival geotechnical research from the 1950s and 1960s, which provided the basis for the reconstruction of the original terrain morphology.	The precise location of the former prison building and the possible location of the buildings of the former royal castle were determined	The probable course of the wall and buildings in the western part of the former royal castle was determined, the places of future research were indicated
6.	South wall of the former royal castle with a donjon undergoing renovation works	Zamkowa Street 9	Laser scanning	100%	The most important source so far is the archival geotechnical research from the 1950s and 1960s, which provided the basis for the reconstruction of the original terrain morphology	The exact shape and location and degree of preservation of the non-existent wall of the former royal castle was determined	Location and layout of some of the defensive objects of the royal castle during the period of the Union of Lublin was determined
7.	Old Town	The area bounded by the city wall in the 14th century (so-called Casimir Walls)	Laser scanning	100%	The tradition of researching the Old Town Hill in Lublin dates back nearly 100 years. The literature of the subject includes hundreds of scientific items and thousands of pages of conservation documentation files. However, due to the lack of cartographic materials from the 16th century, this period has so far been poorly recognized	Laser scanning made it possible to develop a precise three-dimensional model of contemporary city development. A numerical land model and a numerical land cover model have been developed, which is the basic spatial reference for data from archaeological, architectural, historical research and conservation documentation	The connection of the DEM and the DTM with the results of archaeological and geotechnical research made it possible to clarify the original shape of the old town hill and to draw the historical layout of the parcel and communication network. Determination of the original flow directions made it possible to plot the course of the sewage system (gutters). In the reconstruction, the discovered relics of the fourteenth-century city walls and other fortification elements were used, as well as the layout of buildings based on the preserved foundations and stone foundations
8.	The area in front of the Cracow Gate in the course of archaeological works	Łokietek Square	Laser scanning	100%	The Cracow Gate is one of the three surviving relics of the Casimir Wall in Lublin. The object has a rich conservation documentation, its dating and chronological delamination is known. Elements of the moat, bridge and curtain (barbican) have not yet been confirmed	The exact shape and location as well as the degree of preservation of the relics of the building adjacent to the foregate of the Cracow Gate (barbican) were determined. LiDAR measurements were the basis for the spatial reference of further archaeological (excavation) studies	The location, the shape of the elements of the fortifications in front of the Cracow Gate, and the direction of the exit roads during the Union of Lublin were determined
9.	Bernardyńska Street	Bernardyńska Street	Laser scanning	100%	In the years 2000–2002, archaeological surveys were carried out, as part of which historical street surfaces were discovered	As part of the non-invasive test, an accurate terrain height model was made. Thanks to the obtained 3D model and the results of archaeological and geotechnical works, it was possible to create a model of the original shape of the suburbs behind the Bernardines up to the city walls	The layout of the suburban area behind the Bernardines during the Union of Lublin was determined
10.	Sobieski Palace	Bernardyńska Street 13	GPR	100%	Descriptive documentation from architectural supervision and historical research. Iconography	Chronological stratification of the building was made, and in confrontation with the descriptive and iconographic documentation, the development and transformation phases of the architectural form were established	The precise external outline of the original site during the period of the Union of Lublin was determined

No.	Object	Address (modern)	Research technique	Scope of research	Previous state of research	Added value	Information used
11.	The former Bridget Church	Narutowicza Street 10	GPR	100% of the interior of the aisles and the presbytery	Until the time of undertaking the GPR prospectus, no research was conducted inside the church - the knowledge was based on the analysis of source records	The presence of unknown structures was pointed out: walls under the floors, crypt, cemetery with elevated graves, which was verified during archaeological research and was one of the pillars for chronological stratification of the temple	Chronological stratification of the object was worked out, the precise course of the external outline of the object in the 16th century was drawn. The reconstruction of the object's surroundings, monastery buildings and the range of the church cemetery was performed
12.	Lubomirski Palace	Lithuanian Square 3	GPR	100% of the ground floor area	General historical descriptions and analyses	Identification of undiscovered cellars, determination of foundations and underground parts of the object. The development of chronological stratification of the building, additionally confirmed by local archaeological findings	Deletion of the palace's body, reconstruction of the farm buildings situated before the residence. Establishing the course of the residence's defensive wall
13.	Historical Krakowskie Przedmieście (to the west of the second ground fortification line)	Lithuanian Square	Magneto--resistive; GPR; laser scanning; aerial photography	Not more than 50% of the total area	Until the beginning of the 21st century, there was a conviction that this part of Lublin played a marginal role in the history of the city, a lack of empirical research, conclusions based solely on historical analyses	The magneto-resistive (archaeological-geophysical) method in Lithuanian Square was used as the first non-invasive method in Lublin - 2000. In 2015, the geo-radar surveys of the eastern part of Lithuanian Square made it possible to develop an altitudinal model of the parent rock (loess rock). In 2016, geo-radar measurements indicated the presence of relics of brick objects. Excavations have confirmed their existence and dating	Reconstruction of the original terrain. Confirmation of the presence of traces of settlement from the 16th century and later, mentioned in conservation documentation and historical studies
14.	Modern Downtown of Lublin with adjacent areas	Streets: Krakowskie Przedmieście, Narutowicza, Chopin, Okopowa, Lipowa, Radziwiłłowska, Zielona, Staszica	Laser scanning	Around 1 km^2 i.e. nearly 25% of the reconstructed area	General historical recognition, basic chronology of spatial development based on cartographic materials	DEM and DTM of high quality (LiDAR) were obtained from the resources of the Municipal Center for Surveying and Cartographic Documentation. The material was a precise spatial reference for the findings from archaeological, architectural, conservation documentation and others	The confrontation of modern measurement data with the collected cartographic, iconographic and descriptive documentation made it possible to develop a hypothetical model of the original relief. Based on the findings of the research described in the above points, a hypothesis was developed for the layout of plots, buildings, communication network and defensive elements of the western suburbs. A model concept was presented, and the elements currently verified and others requiring further field research were distinguished

Compiled by K. Janus & R. Niedźwiadek (2019)

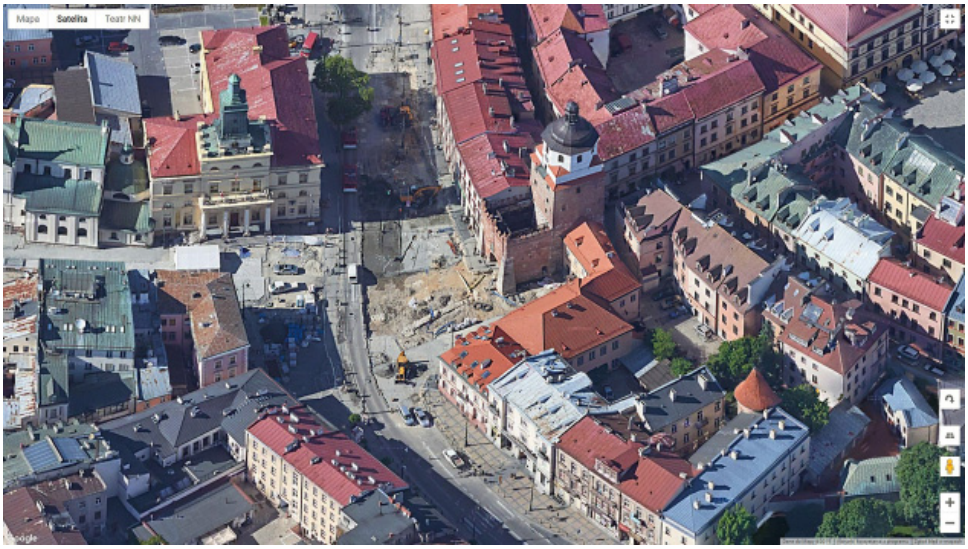

Fig. 2. Portal: www.teatrnn.pl/miejsca/mapa/unia-lubelska – the archaeological discovery of Barbican in front of Cracow Gate (2018). Vertical and diagonal images are available via Google Maps API – satellite (accessed on 7 November 2019)

in particular town zones. Movable historic monuments consisted mainly of ceramic shards and less numerous broken tile pieces and items of everyday use, such as coins and other personal belongings.[22]

Archaeological artefacts, including ceramics and relics of building walls, form the basis for determining relative chronology. Dating is narrowed down to specific architectural or stylistic periods, often covering periods shorter than several dozen years. When dating relics of the Lublin Union period, the authors frequently encountered the following phrases: "sixteenth century", "mid-sixteenth century", and "second half of the sixteenth century". The following date-related phrases were rejected in the dating process: "beginning of the sixteenth century", "first half of the sixteenth century", and "end of the sixteenth century", as these point to the pre-1550 town redevelopment period and the post-1575 period after the Great Fire.

c) Cartographic materials

While reconstructing the historical Lublin space, the authors drew from a vast collection of archival cartographic and iconographic materials (Table 3). Nevertheless, all the relevant sources were created much later than at the time of the Lublin Union. The only map depicting Lublin in the second half of the sixteenth century is *Poloniae, Ltvaniae, Rvssiae, Prvssiae, Masoviae et Scepvsij* – a map by Wacław Grodecki set at a scale of about 1:1,680,000.[23] Unfortunately, using iconic symbols to represent towns only allows for noting their existence. Symbol size may correspond to town prominence to some extent, but one must be very cautious when drawing such conclusions.

The cartographic collection of the State Archives in Lublin and other institutions

[22] P. Zimny, R. Niedźwiadek, M. Grabowski, 'Fosa średniowiecznego Lublina i jej otoczenie w świetle badań interdyscyplinarnych', in *Krakowskie Przedmieście w 450-lecie Unii Lubelskiej*, ed. R. Niedźwiadek (Lublin: Urząd Miasta Lublin, 2019), pp. 201–28.

[23] W. Grodecki, *Poloniae, Ltvaniae, Rvssiae, Prvssiae, Masoviae et Scepvsij chorographia* [map], scale of 1:1,680,000 (Basel, 1562).

Table 3. Archival cartographic sources used for the reconstruction of the space of 16th-century Lublin

No.	Date	Scale	Original title	Author, authors	Language	Technique	Preservation condition	Scope of content	Area covered	Cartometrics	Information used
1.	1649	1:240	Plan okolic Bramy Krakowskiej	K. Bekiewicz	Polish	Multi-coloured manuscript	Partially destroyed (marginal), but rather legible	Detailed situation drawing, parcel geometry, prospective drawing of buildings, street names, signatures	Very small, 0.05 km^2 in front of the Cracow Gate	High GCPs – 12 RMS_1 – 4.60 m RMS_A – 0.72 m	Approximate geometry of buildings, several street names
2.	1716	1:3,400	Plan de la ville et fauxbourgs de Lublin	C.V. d'Örken	French	Multi-coloured manuscript	Very good	Detailed but geometric drawing of buildings, church and public utility markings, course of fortifications and fortifications, layout of roads and bridges, river network, land cover	Average, 3 km^2 includes the Old Town and the Downtown within the limits of 18th-century ground fortifications	Very low, the march-plan, significant distortion of distances and angles GCPs – 29 RMS_1 – 216.75 m RMS_A – 8.73 m	Qualitative information, which requires the correct course to be established on the basis of other materials
3.	Mid-18th century	-	Plan posiadłości szpitala św. Ducha	unknown	Polish and Latin	Monochromatic ink drawing (photocopy)	Average, mostly legible	Simplified road and river network with a prospective drawing of sacred buildings and manors, property descriptions	Small, 0.6 km^2 covers the northern part of Downtown	Very low, situational sketch, significant distortion of distances and angles GCPs – 11 RMS_1 – 51.26 m RMS_A – 14. 58 m	Location of noble manors, churches and monastic estates in the northern part of Downtown
4.	1780 (copied c. 1850)	1:8,300	Mappa generalna całego miasta JKMci Lublina z wszystkiemi polami, zaroślami, łąkami, jurydykami...	S.J.N. Łęcki (copy by M. Billewicz)	Polish	Multi-coloured manuscript	Significantly damaged in the central part, well-preserved drawing of city surroundings	Detailed drawing of the situational content – the plan is a spatial extension of the map described at no. 5	Very large, 150 km^2 covers the entire administrative area of the city within the limits of the end of the 18th century, including all the land belonging to the city, the suburbs and the jurisdicts	Average GCPs – 91 RMS_1 – 29.17 m RMS_A – 3.90 m	The division of properties surrounding the city in the 18th century, used as a basis for retrogression
5.	1783 (copied in 1852)	1:5,000	Mappa całego miasta JKMci Lublina z wszystkiemi Ulicami, Przedmiesciami, Jurydykami...	S.J.N. Łęcki (copy by F. Bieczyński)	Polish	manuscript	Partially destroyed (marginal), but rather legible	Detailed drawing of the situation content, geometry of free-standing buildings, built-up parcels, fortifications, forms of land use, layout of roads and bridges, river network, land division, signature and descriptive markings	Large, 24 km^2 covers the entire built-up area of the city from the end of the 18th century and the suburbs of Kalinowszczyzna, Piaski and Wieniawa	High GCPs – 357 RMS_1 – 13.35 m RMS_A – 0.74 m	Geometry of the situation drawing in the 18th century, used as a basis for retrogression

6.	1783 (copied in 1802)	1:2,500	Mappa der granzen königl. Stadt Lublin sam allen Gassen, Vorstadten, Jurisdikzionen	S.J.N. Łęcki (copy by J. Kierłowicz)	German (Austrian)	manuscript	Average, mostly legible	Detailed drawing of the situational content – the plan is an enlarged drawing of the map described at no. 5. in a simplified graphic form, slight changes of content	Large, 24 km^2 covers the entire built-up area of the city from the end of the 18th century and the suburbs of Kalinowszczyzna, Piaski and Wieniawa	High GCPs – 279 RMS_1 – 17.73 m RMS_A – 1.35 m	Verification of the content of the map no. 5.
7.	1789 (undated copy)	1:5,000	Ordys Jurydyki Wieniawy z Czechówką Górną i Dolną z mappy Miasta Lublina przez Jeometrę Łąckiego w roku 1789 sporządzony	S.J.N. Łęcki (unknown copyist)	Polish	Multi-coloured manuscript	Very good	Detailed drawing of the situational content – the plan is a fragment of the map described at no. 4	Average, 6 km^2 covers the suburbs of Wieniawa, villages Czechówka Górna and Czechówka Dolna	High GCPs – 37 RMS_1 – 30.37 m RMS_A – 1.75 m	Substitute for the drawing of damaged area in map no. 4.
8.	1800	1:5,760	Afnahmsblatt der Stadt Lublin	E. Renner	German (Austrian)	Multi-coloured manuscript	Very good	Seemingly detailed drawing of the situational content, geometry of buildings, marking of churches and public buildings, course of fortifications and fortifications, layout of roads and bridges, river network, land cover, signature and descriptive markings	Average, 4 km^2 covers the entire built-up area of the city from the end of the 18th century and the suburbs of Kalinowszczyzna, Piaski and Wieniawa	Very low, the marchplan, significant distortion of distances and angles GCPs – 76 RMS_1 – 121.70 m RMS_A – 5.43 m	Qualitative information, which requires the correct course to be established on the basis of other materials
9.	1803	1:14,400	Plan der West Galizischen Kreis Stadt Lublin nebst der umliegenden Gegend	J. Tretter	German (Austrian)	Multi-coloured manuscript, high aesthetics	Very good	Detailed drawing of the situation, building geometry, marking of churches and public buildings, course of fortifications and fortifications, layout of roads and bridges, river network, land cover, signature and descriptive markings, rich relief of the terrain	Very large, 72 km^2 covers the administrative area of the city within the borders of the early 19th century, and the surroundings	In the area of the city's built-up area, low, it reproduces the distortions of the map no. 8. Outside the city – average GCPs – 88 RMS_1 – 29.68 m RMS_A – 2.05 m	Topography of the area outside the urban fortification, landscape

No.	Date	Scale	Original title	Author, authors	Language	Technique	Preservation condition	Scope of content	Area covered	Cartometrics	Information used
10.	1801–1804	1:28,800	Carte von West Gallizien, col. XV sect. 195	unknown Officer, (under supervision of A.M. von Heldensfeld)	German (Austrian)	Multi-coloured manuscript, high aesthetics	Very good	Detailed drawing of the situation, building geometry, marking of churches and public buildings, course of fortifications and fortifications, layout of roads and bridges, river network, land cover, signature and descriptive markings, rich relief of the terrain	Very large, 223 km^2 covers the administrative area of the city within the borders of the early 19th century, and the surroundings	In the area of the city's built-up area, low, it reproduces the distortions of the map no. 8. Outside the city – average GCPs – 40 RMS_1 – 32.58 m RMS_A – 5.55 m	Topography of the area outside the urban fortification, landscape drawing
11.	1827 (copied in 1959)	1:2,250	Kopia płana goroda Lublina	W. Ziółkowski (copy by R. Jaruga)	Russian	Monochromatics copy (ozalide paper)	Very good	Detailed drawing of buildings, parcels, road and river network, street and river names, parcel numbering	Average, 6 km^2 covers the entire built-up area of the city from the first half of the 19th century, including the suburb of Piaski	Very high GCPs – 652 RMS_1 – 4. 18 m RSM A – 0.09 m	Intermediate map used to calibrate older maps, relics of urban fortifications and historical shape of buildings were confirmed
12.	1836 (copied in 1866)	1:2,500	Plan miasta Lublina	B. Maciejowski	Polish	Multi-coloured manuscript	Good	Detailed drawing of buildings, parcels, road and river network, street and river names, other toponyms	Average, 10 km^2 covers the entire built-up area of the city from the first half of the 19th century, including the suburbs of Kalinowszczyzna and Piaski	Very high GCPs – 312 RMS_1 – 8.24 m RMS_A < 0.1 m	Intermediate map used to calibrate older maps, relics of urban fortifications and historical shape of buildings were confirmed
13.	1876	1:2,500	Plan goroda Lublina	unknown	Rusisan	Multi-coloured manuscript	Good, unfortunately, map was sliced in 20 parts (5x4) and glued on canvas	Detailed drawing of buildings, parcels, road and river network, street and river names, parcel numbering. Unfortunately in some parts parcels are too generalized or missing.	Average, 10 km^2 covers the entire built-up area of the city from the second half of the 19th century, including the suburb of Kalinowszczyzna	Low, significant distortions of the peripheral areas, probably poorly compiled of several smaller maps GCPs – 786 RMS_1 – 71.29 m RMS_A < 7.49 m	Intermediate map used to calibrate older maps, relics of urban fortifications and historical shape of buildings were confirmed
14.	1888–1890 (copied in 1914–1915, then recopied in 1929)	1:21,000 (nominal) 1:25,000 (copy)	Novaja Topograficeskaja Karta Zapadnoj Rosiji – so-called Half-Verst map, copied by the Germans during WW1, then recopied by the Polish MGI	unkonown	Rusisan	Monochromatic print	Good, unfortunately the content is barely legible due to quality loss when reprinting	Full	Very large, over 147.5 km^2	Average, GCPs – 34 RMS_1 – 12.41 m RMS_A < 1.02 m	Intermediate map used to calibrate older maps, drawing of terrain outside the city

15.	1928	1:1,000	Plan Wielkiego Miasta Lublina	Lublin Municipal Office, Department of Measurements	Polish	Monochromatic print	Very good	Full	Large, 28.5 km^2 covers the entire area of the city after its administrative extension in 1928	Very high, comparable to modern reference data GCPs – 1231 RMS_1 – 1.98 m RMS_A < 0.01 m	Intermediate map used to calibrate earlier maps, multiple preserved historical buildings from the 16th-century or older
16.	1934	1:15,000	Plan Wielkiego Miasta Lublina	Lublin Municipal Office, Department of Measurements	Polish	Monochromatic print	Poor, mostly legible but very crumpled	Detailed drawing of buildings, road and river network, street and river names. In some parts, buildings too generalised, some roads projected never came into existence	Large, 28.5 km^2 covers the entire area of the city after its administrative extension in 1928	Average GCPs – 710 RMS_1 – 16.63 m RMS_A < 1.51 m	Intermediate map used to calibrate earlier maps, multiple preserved historical buildings from the 16th-century or older
17.	1947	1:10,000	Lublin	Lublin Municipal Office, Department of Measurements	Polish	Monochromatic copy (ozalide paper)	Good, scanned in 4 parts, then stitched in graphic software	Detailed drawing of buildings, parcels, road and river network, street and river names. Unfortunately, bad image stitching is noticeable in the northern part of the map	Large, c. 30 km^2 covers the entire area of the city after its administrative extension in 1946	Average GCPs – 493 RMS_1 – 22.88 m RMS_A < 0.01 m	Intermediate map used to calibrate earlier maps
18.	1977–1978	1:10,000	Mapa topograficzna Polski w układzie "1965" – topographical map of Poland	Main Office of Geodesy and Cartography	Polish	WMS service	-	Full	Very large, over 147.5 km^2	Reference topographical map 1:10,000 with pixel sampling 1.0 x 1.0 m	Intermediate map used to calibrate earlier maps
19.	2000–2001	1:10,000	Mapa topograficzna Polski w układzie "1992" – topographical map of Poland	Main Office of Geodesy and Cartography	Polish	WMS service	-	Full	Very large, over 147.5 km^2	Reference topographical map 1:10,000 with pixel sampling 1.0 x 1.0 m	Intermediate map used to calibrate earlier maps
20.	2019	1:10,000 nominal 1:500 for buildings	Baza Danych Obiektów Topograficznych (BDOT10k) – database of topographical objects at scale 1:10000	Main Office of Geodesy and Cartography	Polish	XML vector data format	-	Full	Very large, over 147.5 km^2	Reference topographical data, similar to master map 1:500. inaccuracy < 0.075 m	Modern reference topographical data, preserved historical buildings from the 16th-century or older were selected

No.	Date	Scale	Original title	Author, authors	Language	Technique	Preservation condition	Scope of content	Area covered	Cartometrics	Information used
21.	2019	Approx. 1:2,000	Ortofoto-mapa standardowa (usługa WMTS) – standard ortophoto Web Map Tiled Service at geoportal.gov.pl	Main Office of Geodesy and Cartography	Polish	WMTS tiles, also .TIF raster data format available for download	-	Full	Very large, over 147.5 km^2	Reference orthorectified aerial images with pixel sampling 0.1 x 0.1 m	Modern reference image, used to verify GCPs
22.	2019	Approx. 1:2,000	Numeryczny Model Terenu (NMT) – Digital Terrain Model	Main Office of Geodesy and Cartography	Polish	ASCII raster data format available for download	-	Full	Very large, over 147.5 km^2	Reference terrain data, with pixel sampling 0.5 x 0.5 m and height accuracy +/- 0.1 m	Modern reference terrain data modified to model the 16th-century landscape
23.	2019	Approx. 1:2,000	Numeryczny Model Pokrycia Terenu (NMPT) – Digital Surface Model	Main Office of Geodesy and Cartography	Polish	ASCII raster data format available for download	-	Full	Very large, over 147.5 km^2	Reference surface data, with pixel sampling 0.5 x 0.5 m and height accuracy +/- 0.1 m	Modern reference surface data used for modelling the height of preserved 16th-century buildings

GCPs – Ground Control Points, RMS_1 – total Root Mean Square Error (RMSE, Gaussian) at 1st order transformation, RMS_A – total Root Mean Square Error (RMSE, Gaussian) at composed rubber-sheeting transformation 'TPS/adjust' method. Compiled by J. Kuna (2019).

related to Lublin's history offer several dozen maps and plans of the entire town and several hundred plans of selected town areas (districts, streets, estates).[24] Although an extensive array of resources was used to recreate the map of sixteenth-century Lublin, this article presents only a brief enumeration of the most vital cartographic sources.

The oldest surviving cartographic document is the 1649 handwritten plan of the surroundings of Cracow Gate by Karol Bekiewicz. The 1:240 plan presents the part of the town neighbouring the Cracow Gate, including Korce Square, and fragments of two streets: Krakowskie Przedmieście and Żmigród. "The plan is rich in detail and content description, which enables recreating the buildings and urban layout [...] in the centre of sixteenth-century Lublin. Objects which have not survived to the present day are also visible".[25] A shortcoming of the plan is its limited coverage, as it shows a surface area of barely 5 ha, corresponding to less than 1 per cent of the explored area.[26]

The first cartographic study depicting Lublin is the 1716 *Plan de la ville et fauxbourgs de Lublin* by C.V. d'Örken. This manuscript was set at a scale of approximately 1:3,400. Plan coverage is outlined by the eighteenth-century town fortifications (present-day Lipowa Street) to the west and by the marshy valleys of Bystrzyca and Czechówka Rivers to the south, east and north. As this plan was hastily drawn up for the Tarnogród Confederation negotiations taking place in the town, it is marked by great simplicity. Notably, distorted spatial relations render the plan useless as background material, which does not detract from its high informational value.[27]

The 1783 *Mapp of the Whole City of Lublin of His Majesty the King* made by Stanisław Jan Nepomucen Łęcki proved to be the most important, as well as the cartographic basis for the retrogression of Lublin's historical landscape. Since the original plan had been lost, the authors were forced to resort to its three surviving copies made by Jan Kierłowicz in 1802 (1:2,500, in German), Feliks Bieczyński in 1852 (1:5,000, in Polish), and Mieczysław Pawlak in 1941 (1:5,000, in German).[28] Plan copies vary in drafting techniques and, to a minor extent, their rendering of the depicted content. Digital copies of all three documents were analysed. The Polish copy by Feliks Bieczyński (Fig. 3) offered the best quality, legibility and cartometricity; the remaining plans were used as supporting materials.

After the Habsburg Monarchy annexed the northern part of the Lublin Region, the Austrian army drafted three topographical maps of Lublin in the late eighteenth and early nineteenth centuries. The maps were authored by Emanuel Renner (1800), Johann Tretter (1803), and Anton Mayer von Heldensfeld (1804).[29]

[24] Cf. M. Harasimiuk, D. Kociuba, P. Dymmel (eds), *Plany i widoki Lublina XVII–XXI wiek* (Lublin: PTTK, 2007); Lubelskie Archiwum Cyfrowe (Lublin Digital Archives), www.lac.lublin.pl (accessed on 27 Oct. 2019); Keywords 'plans of Lublin' and 'maps of Lublin' at www.teatrnn.pl: http://teatrnn.pl/leksykon/tagi/plany-lublina/ and http://teatrnn.pl/leksykon/tagi/mapy-lublina/ (accessed on 27 Oct. 2019).

[25] D. Kociuba, 'Analiza treści i okoliczności powstania planów i widoków Lublina', in *Plany i widoki Lublina*, pp. 108–09.

[26] A digital version of the plan, see K. Nieścioruk, *Karol Bekiewicz "Plan miasta Lublina" z 1649 roku*, https://teatrnn.pl/leksykon/artykuly/karol-bekiewicz-plan-miasta-lublina-z-1649-roku/, (accessed on 27 Oct. 2019).

[27] K. Nieścioruk, 'Analiza i ocena XVIII-wiecznego planu Lublina jako przykład kompleksowych badań dawnych materiałów kartograficznych', *Polski Przegląd Kartograficzny*, vol. 39, no. 2 (2007), pp. 146–58; K. Nieścioruk, 'C. d'Örken "Plan De la Ville et Fauxbourgs de Lublin" z 1716 roku', http://teatrnn.pl/leksykon/artykuly/c-d-orken-plan-de-la-ville-et-fauxbourgs-de-lublin-z-1716-roku/ (accessed on 27 Oct. 2019).

[28] P. Dymmel, 'Plany Lublina w zasobach archiwalnych', in *Plany i widoki Lublina*, pp. 88–97.

[29] E. Renner, *Aufnahmsblatt der Stadt Lublin*, 1800, scale of 1:5,760; J. Tretter, *Plan der Westgallizischen Kreistadt Lublin nebst umliegenden Gegend*, 1803, scale of 1:14,400; A.M. Heldensfeld, *Carte von West Gallizien*, 1804, scale of 1:28,800, sheet 195. Cf. M. Trzewik, 'Układ przestrzenny miasta Lublina na przełomie XVIII i XIX wieku na planach austriackich przechowywanych w Archiwum Wojennym w Wiedniu', in *Dawne mapy jako źródła w badaniach geograficznych i historycznych*, ed. B. Konopska, J. Ostrowski, Series: Z dziejów kartografii, vol. 18

Fig. 3. Mappa całego miasta J.K. Mci Lublina z wszystkiemi ulicami, przedmieściami, jurydykami … roku 1783 delineowana, scale of 1:5,000, Lublin, 1783, Stanisław Łęcki (tracing by F. Bieczyński of 1852), State Archives in Lublin, Plans of Lublin Town, ref. no. 3, approx. 9% of original size; digital copy available at www.lac.lublin.pl/plany/calosci/sygn-3 (accessed on 7 Nov. 2019), and as an interactive map at https://teatrnn.pl/miejsca/mapa/lublin-schylek-xviii-wieku/ (accessed on 13 Sep. 2024)

The hand-drawn maps provide a consistent array of scales: from the most detailed 1:5,760 plan, through a topographical photograph of the town and surrounding areas set at a scale of 1:14,400, to a multisheet map at 1:28,800 – the final map produced for the entire region. Successive sources proved increasingly less detailed and replicated the content of larger-scale studies (in generalised form). Even if one recognises the logic and ergonomics behind these decisions, it should be stressed that Emanuel Renner's map is simultaneously the most detailed and the least cartometric. Renner's plan unusually distorts distances, angles and surface areas (for a source created during modern triangulation). Consequently, this also negatively affects the maps of Johann Tretter and Anton Mayer von Heldensfeld. Measurement and drawing are excellent in rural areas, but the area within Lublin fortifications is not barometric. The maps by Johann Tretter and Anton Mayer Heldensfeld formed the basis for retrogressing town surroundings, like that of C.V. d'Örken, Emanuel Renner's plan served only as a source of qualitative information (Table 3).

d) Iconography

For the reconstruction process, the authors employed six landscapes (*vedute*) dating back to 1618, 1719, 1774, 1803, 1826 and 1840.[30] These iconographic sources have varied creation dates and sizes, are the outcome of varied art techniques, and offer dissimilar depictions of topographical details and spatial relationships. The oldest print, *Tipus Civitatis Lublinensis* (Fig. 4), is an engraving which presents the town from several observation points located to the south, southeast and east. *The Fire of the Town in 1719* is the only painting depicting Lublin from the north. The four remaining panoramas present Lublin from the south or southeast. Translating the subjective spatial relationships of landscape art into actual map dimensions was very challenging. Nevertheless, the high level of detail adds significant value to the engravings as factual material. A cross-verification with cartographic material, historical-architectural documentation and archaeological findings confirmed multiple nuances in the engravings.

3. Modern reference data and georeferencing of old maps

Harmonising the mathematical basis of the source materials was indispensable to ensure the correct evaluation of cartographic archival data and warrant coherence between the reconstructed map of Lublin in the Lublin Union period and contemporary spatial data. To this end, tools and methods were used to calibrate the old maps.[31] A modern georeferenced dataset tied to the local coordinate system was the basis for calibrating Lublin's archival plans and maps.[32] The authors used

(Warszawa: Wydawnictwa IHN PAN – Instytut Geodezji i Kartografii, 2014), pp. 155–67; J. Jeremicz, T. Woźny, 'Tretter's Plan of Lublin (1803)', https://teatrnn.pl/leksykon/artykuly/plan-lublina-trettera-1803-rok/.

[30] F. Hogenberg, 'Tipus Civitatis Lublinensis in Regno Poloniae…', in G. Braun, F. Hogenberg, *Civitates orbis terrarum*, vol. 6 (Coloniae Agrippinae, 1618); *Pożar miasta Lublina w 1719 r.* [Fire of Lublin Town in 1719], Lublin – wall painting in the Dominican Church in Lublin, unknown author, 1st half of the 18th c.; J. Maszewski, *Lublin/Vera Effigies Imaginis S. Antonii…*, Lublin, 1774, National Museum in Lublin, engraving, 58 × 39.5 cm, ref. no. S/G/268/ML; J. Tretter, Panorama of the Town, in *Plan der Westgalizischen Kreistadt Lublin nebst der umligenden Gegend* (Wien, 1803); Ph. Dombeck, *Wjazd generała Zajączka do Lublina w 1826 r.,* Lublin 1826; P.E. Hackert, *Widok miasta Lublina z strony rogatki piaseckiey,* Lublin 1840; after: Kociuba, 'Analiza treści', pp. 119–25; ead., *Lublin. Rozwój przestrzenny i funkcjonalny*; Trzewik, 'Układ przestrzenny miasta Lublina'.

[31] J. Kuna, 'Metodyczne aspekty analiz przestrzennych GIS wykorzystujących dawne mapy topograficzne', in *Dawne mapy topograficzne w badaniach geograficzno-historycznych*, ed. A. Czerny (Lublin: Wydawnictwo UMCS, 2015), pp. 125–49; M. Jaskulski, G. Łukasiewicz, M. Nalej, 'Porównanie metod transformacji map historycznych', *Roczniki Geomatyki*, vol. 11, no. 61 (2013), pp. 41–57.

[32] Modification of the PL-2000 system. The boundary between zones 7 and 8 passes through Lublin. As this peripheral location negatively affects map orientation, the authors used the central meridian of 22.568 E, which runs through the tip of the Trinitarian Tower, which became the starting point of the local coordinate system. Cf. Regulation of the Council of Ministers of 15 October 2012 on the National Spatial

Fig. 4. F. Hogenberg, Tipus Civitatis Lublinensis in Regno Poloniae…, in G. Braun, F. Hogenberg, Civitates orbis terrarum, vol. 6 (Coloniae Agrippinae, 1618); National Museum in Lublin, S/G/271/ML, 24% of the original size; digital copy available at https://wmuzeach.pl/wszystkie-obiekty/1bW8CFW4KNK4rMqlua42_widok-lublina-tipus-civitatis-lublinensis-in-regno-poloniae-?search_token=f6hiiwYtfodR0y1Nz2DB&sortby=created_at-desc (accessed on 9 Jan. 2024)

historic buildings from the buildings layer of the Database of Topographic Objects (BDOT10k) to establish the ground control points (GCPs).[33] In ambiguous cases, the authors referred to other data from the geoportal of the Central Office of Geodesy and Cartography (www.geoportal.gov.pl), i.e. the orthophotomap (WMTS service) and the topographic map at a scale of 1:10,000 (WMS service – series). Other auxiliary sources included the 'A' register of immovable artefacts maintained by Lubelskie Voivodeship, the Municipal Register of Historic Monuments and the WMS services of the National Heritage Institute Geoportal.[34]

The re-georeferencing of old Lublin maps and plans focused on a series of cartographic materials arranged from the most recent and accurate, through those relating to the Second World War and the inter-war period, to materials from the nineteenth and eighteenth centuries (Fig. 5). To this end, the authors used

Reference System (references to the Polish Journal of Laws: Dz.U. of 2010, no. 193, item 1287), pp. 3, 16–17.

[33] The Database of Topographic Objects, with topographic map detail of 1:10,000 (BDOT10k), is a rich dataset of 286 object types grouped into 57 classes, representing nine categories: (1) water network; (2) transport network; (3) utility network; (4) land cover; (5) buildings, structures and facilities; (6) land use complexes; (7) protected areas; (8) territorial division units; (9) other objects. Cf. Regulation of the Minister of Development, Labour and Technology of 27 July 2021 on the Database of Topographic Objects and the Database of General Geographic Objects, as well as Standard Cartographic Studies (references to the Polish Journal of Laws: Dz.U. of 2021, item 1412).

[34] NID Geoportal, https://mapy.zabytek.gov.pl/nid/; Announcement No. 1/2023 of the Lubelskie Voivodship Conservator of Monuments in Lublin of 24 January 2023 on the list of monuments entered in the register of immovable monuments of the Lubelskie Voivodship and in the register of archaeological monuments of the Lubelskie Voivodship, https://wkz.lublin.pl/rejestr-zabytkow-3/.

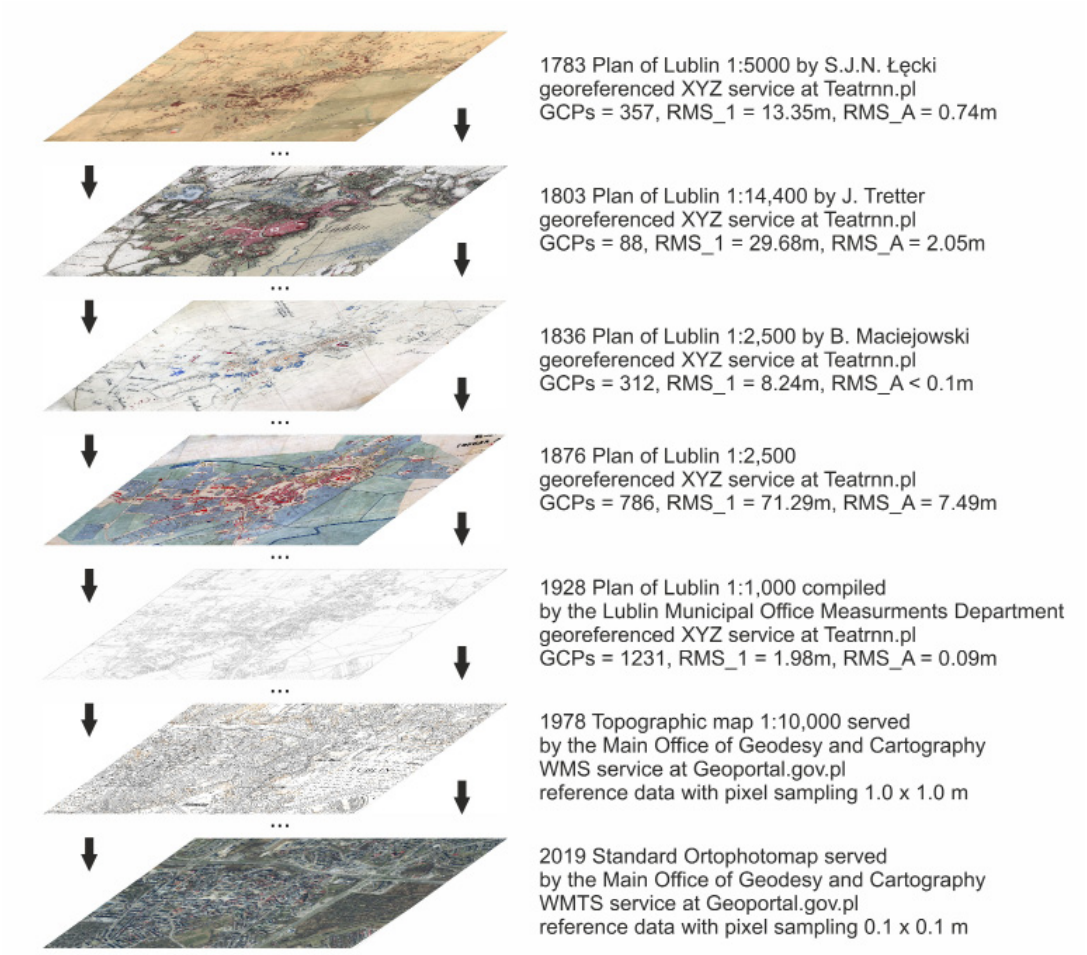

Fig. 5. Re-georeferencing a series of cartographic archival layers. Table 3 evaluates the degree of inaccuracy of individual maps regarding cartographic material matching using the first-degree polynomial and spline function (TPS/adjust) methods. Table 4 assesses the accuracy of individual objects recreated in the map. Compiled by J. Kuna

several own studies drafted as part of previous research projects.[35] Reference point selection was based on meticulously analysing all previously matched materials. On multiple occasions, the number of control points per sheet exceeded ten (Table 3). When qualifying reference points and evaluating distortion, we applied objective criteria which took the source map scale into account (Tables 4–5). The bulk of the layers are single-sheet archival materials. However, the collection also provides multi-sheet maps, which must be skilfully merged into a digital environment. Apart from Łęcki's 1780 and 1783 maps, the previously georeferenced 1930 Plan of the Great Town of Lublin, drawn on 102 sheets at a scale of 1:1,000, played a key yet indirect role.[36]

[35] The complete list of interactive maps of the Lublin Historical Geoportal (Lublin HGIS) is available at https://teatrnn.pl/miejsca/mapy/.

[36] See interactive map: J. Kuna et al., 'Lublin, lata 20. i 30. XX wieku', https://teatrnn.pl/miejsca/mapa/lublin-1920-1930/; Kuna, Kowalski, 'Exploring a non-existent city', pp. 328–32.

*Table 4. Geographic and geometric evaluation of historical data referring to standards of modern spatial data in Poland**

Error threshold on the map [mm]		Reference scale							
		BDOT500 or master maps				BDOT10k	Generalised topographic maps		
		Urban area		Rural area					
		1:500	1:1,000	1:2,000	1:5,000	1:10,000	1:25,000	1:50,000	1:100,000
		Terrain accuracy [m]							
Shape	0,15 mm	0.075 m	0.15 m	0.3 m	0.75 m	1.5 m	3,75 m	7.5 m	15 m
Location	1.0 mm	0.5 m	1.0 m	2.0 m	5.0 m	10.0 m	25.0 m	50.0 m	100.0 m
Evaluation of historical data vectorisation		High		Moderate			Low		Very low

Criteria for assessing the accuracy of historical data geometries in relation to official georeferenced databases and standard cartographic products. With reference to the criteria outlined above, Table 3 provides an assessment of the inaccuracy of the matching of cartographic materials by 1st degree polynomial and segmented function ‚TPS/adjust' methods for individual maps. Table 4 summarises the accuracy assessment of individual objects reconstructed on the map. Compiled by J. Kuna (2019).

** Concerning the above criteria, Table 3 uses the first-degree polynomial and spline function (TPS/adjust) methods to evaluate individual maps regarding the inaccuracy of cartographic material matching. Table 4 collates the accuracy assessment of individual reconstructed objects in the map. Source: Compiled by J. Kuna*

Table 5. Geographic, geometric and descriptive accuracy of objects used for the reconstruction of the space of 16th-century Lublin

No.	Object type	Number of objects	Current status	Geographic accuracy (location prediction)	Geometric accuracy (shape)	Descriptive accuracy (classification)	Information sources							
							BDOT10k	1928 master map 1:1000	Archaeological excavations and supervision	Architectural supervision	Archival plans (1:1000 or better)	Archival maps (1:2500 or worse)	Historical studies	Descriptive sources
1.	Royal Castle Chapel	1	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	+	+	+	+	+	+	+	+
2.	Royal Castle Tower (*wieża*)	1	Preserved (minor changes)				+	+	+	+	+	+	+	+
3.	Royal Castle Tower (*baszta*)	1	Preserved ruin				+	+	+	+	+	+	+	+
4.	Royal Castle - other buildings	16	Not preserved				-	-	+	+	+	+	+	+
5.	Royal Castle - other buildings	13	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)		-	-	-	-	-	+	+	+
6.	City hall	1	Preserved (major changes)	High (1m or better)	High (with precise size and shape)		+	+	+	+	+	+	+	+
7.	City gate (major fortification - *brama*)	2	Preserved (minor changes)				+	+	+	+	+	+	+	+
8.	City gate (major fortification - *brama*)	1	Not preserved				+	+	+	+	+	+	+	+
9.	City gate (minor fortification - *furta*)	1	Preserved (major changes)				-	-	+	+	+	+	+	+
10.	City gate (minor fortification - *furta*)	7	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)		-	-	-	-	-	+	+	+
11.	Barbican (fortification)	1	Discovered with precise archaeological context				-	-	+	-	-	+	+	+

No.	Object type	Number of objects	Current status	Geographic accuracy (location precision)	Geometric accuracy (shape)	Descriptive accuracy (classification)	Information sources								
							BDOT10k	1928 master map 1:1000	Archaeological excavations and supervision	Architectural supervision	Archival plans (1:1000 or better)	Archival maps (1:2500 or worse)	Historical studies	Descriptive sources
12.	Tower (*baszta*)	1	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	+	+	+	+	+	+	+	+
13.	Tower (*baszta*)	2	Preserved (major changes)				+	+	+	+	+	+	+	+
14.	Tower (*baszta*)	2	Preserved ruin				+	+	+	+	+	+	+	+
15.	Tower (*baszta*)	11	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)		-	-	+	-	-	+	+	+
16.	City wall section	3	Preserved ruin	High (1m or better)	High (with precise size and shape)		+	+	+	+	+	+	+	+
17.	City wall section	5	integrated into an existing buildings				-	-	+	+	+	+	+	+
18.	City wall section	23	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)		-	-	+	-	-	+	+	+
19.	Church	4	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)		+	+	+	+	+	+	+	+
20.	Church	2	Preserved (major changes)											
21.	Church	1	Preserved ruin				+	+	+	+	+	+	+	+
22.	Synagogue	1	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)		-	+	+	-	+	+	+	+
23.	Monastery	3 orders (total 10 buildings)	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)		+	+	+	+	+	+	+	+

24.	Monastery	1	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)	High (appears in numerous descriptive and graphic sources)	-	-	+	-	-	+	+	+
25.	Other walls (fortified monastery or manor, etc.)	7	Preserved ruin	High (1m or better)	High (with precise size and shape)		+	+	+	+	+	+	+	+
26.	Other walls (fortified monastery or manor, etc.)	8	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)	Moderate (appears in several descriptive sources)	-	-	+	-	-	+	+	+
27.	Manor	2	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	+	+	+	+	+	+	+	+
28.	Manor	8	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)	Moderate (appears in several descriptive sources)	-	-	+	+	+	+	+	+
29.	Brewery	1	Preserved (major changes)	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	-	-	+	+	+	+	+	+
30.	Brewery	3	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)	Moderate (appears in several descriptive sources)	-	-	+	-	-	+	+	+
31.	Pottery workshop	1					-	-	+	-	-	+	+	+
32.	Foundry	1					-	-	+	-	-	+	+	+
33.	Public bath	1					-	-	-	-	-	+	+	+
34.	Watermill	3					-	-	-	-	-	+	+	+
35.	Water tower	1	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	+	+	+	+	+	+	+	+
36.	Remnants of water supply	2	Discovered with precise archaeological context				-	-	+	+	+	+	+	+

No.	Object type	Number of objects	Current status	Geographic accuracy (location precision)	Geometric accuracy (shape)	Descriptive accuracy (classification)	Information sources							
							BDOT10k	1928 master map 1:1000	Archaeological excavations and supervision	Architectural supervision	Archival plans (1:1000 or better)	Archival maps (1:2500 or worse)	Historical studies	Descriptive sources
37.	Townhouse	36	Preserved (minor changes)	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	+	+	+	+	+	+	+	+
38.	Townhouse	27	Preserved (major changes)				-	-	+	+	+	+	+	+
39.	Brick house	15	Rebuilt differently				-	-	+	+	+	+	+	+
40.	Brick house	11	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)	Moderate (appears in several descriptive sources)	-	-	-	-	-	+	+	+
41.	Wooden house	3	remnants integrated into an existing buildings	High (1m or better)	High (with precise size and shape)		-	-	+	+	+	+	+	+
42.	Wooden house	25	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)		-	-	-	-	-	+	+	+
43.	Outbuilding	2	Rebuilt differently	High (1m or better)	High (with precise size and shape)		-	-	+	+	+	+	+	+
44.	Outbuilding	21	Not preserved	Moderate (10m or better)	Moderate (with general size and shape)	Low (single references or circumstantial evidence)	-	-	-	-	-	+	+	+
45.	remnants of cellars	6	integrated into an existing buildings	High (1m or better)	High (with precise size and shape)		-	-	+	+	+	+	+	+
46.	remnants of unknown buildings	3					-	-	+	+	+	+	+	+
47.	remnants of unknown buildings	18	Discovered with precise archaeological context	High (1m or better)	High (with precise size and shape)		-	-	+	+	-	+	+	+
48.	Other traces of settlement (pottery, personal belongings, coins)	13					-	-	+	-	-	+	+	+

49.	Other traces of settlement (pottery, personal belongings)	18	Discovered with uncertain archaeological context	Moderate (10m or better)	Moderate (with general size and shape)	Low (single references or circumstantial evidence)	-	-	+	-	-	+	+
50.	Cloacal pit (with pottery and coins)	2	Discovered with precise archaeological context	High (1m or better)	High (with precise size and shape)		-	-	+	-	+	+	+
51.	Cloacal pit (with pottery)	2	Discovered with uncertain archaeological context	Moderate (10m or better)	Moderate (with general size and shape)		-	-	+	-	+	+	+
52.	City moat (with pottery and coins)	1	Discovered with precise archaeological context	High (1m or better)	High (with precise size and shape)	High (appears in numerous descriptive and graphic sources)	-	-	+	-	+	+	+
53.	Castle moat (with pottery)	1	Discovered with uncertain archaeological context	Moderate (10m or better)	Moderate (with general size and shape)	Moderate (appears in several descriptive sources)	-	-	+	-	+	+	+
54.	Other findings	17		High (1m or better)	High (with precise size and shape)	Low (single references or circumstantial evidence)	-	-	+	-	-	+	+
Core data – total							360						
55.	Probable settlements (suburbs)	122	Not preserved	Low (10m or worse)	Moderate (with general size and shape)	Low (registered number of houses and owners but no certain location)	-	-	-	-	-	+	+
56.	Probable settlements (other)	453			Low (no information about size and shape)	Very low (general description only)	-	-	-	-	-	-	+
Supplementary objects (map only) – total							575						

Summary

Objects	Geographic accuracy (location)		Geometric accuracy (shape)		Descriptive accuracy (classification)	
	number	account	number	account	number	account
High	211	22.6%	211	22.6%	203	21.7%
Moderate	149	15.9%	271	29.0%	67	7.2%
Low	575	61.5%	453	48.4%	222	23.7%
Very low	-	0.0%	-	0.0%	453	48.4%

Compiled by J. Kuna (2019).

4. Reconstructing sixteenth-century Lublin

The collected descriptive, iconographic, and cartographic sources were critically evaluated and analysed. The authors focused on the 1575 fire, which consumed a substantial part of Lublin and its suburbs.[37] The fire that swept across the town destroyed a notable portion of sixteenth-century documents and objects dating back to the Union of Lublin. In the early seventeenth century, intensive post-fire urbanisation and royal privileges to use "stone from the nearby Tatary mountain" for house construction led to the obliteration of the former building layout.[38] As it proved infeasible to entirely base town reconstruction on sources pre-dating the Union of Lublin, we adopted the principle of dividing the reconstructed space into smaller sub-areas. We classified buildings adjacent to main town streets, mentioned in the sixteenth century, based on the historical sources outlined in Chapter 2 or by retrogressing data on buildings remodelled in later centuries. Terrain and surface waters were mapped after several papers by the following Lublin geographers: Piotr Demczuk, Marian Harasimiuk, Dagmara Kociuba, Waldemar Kociuba, Przemysław Mroczek, Jan Reder, Jan Rodzik, Jolanta Rodzoś, Józef Jan Superson, and Wojciech Jakub Zgłobicki. These scientific publications encouraged the authors to conduct their own spatial data and maps analyses, including the Digital Elevation Model (NMT) and the 1:50,000 Detailed Geological Map of Poland (SMGP).[39]

a) "The Town within the Walls", the Castle, and Podzamcze

In the analysed period, the town centre was surrounded by medieval walls (Fig. 6). Located in the centre of the town square, the town hall was the centrepiece of Lublin. Stone and brick tenement houses surrounded it. Present-day Grodzka Street served as the thoroughfare of this part of the town, connecting Grodzka Gate and Krakowska Street (present-day Bramowa Street). The latter street was an extension of the roadway leading to Cracow Gate. The streets of Różana (present-day Olejna) and Łazienna (present-day Rybna and Ku Farze) branched off the main road.[40] Property types outside of the market square depended on the wealth of parcel owners. Brick and wooden houses and timber homes were erected on stone foundations.[41] Gardens, orchards, and spaces for practising handicrafts occupied the back of the built-up plots. St Stanislaus Street (present-day Złota Street) led from the market square to the Dominican Church of the same name. St Michael's Parish Church was the second house of worship within town walls; its reconstructed foundations are now displayed at Po Farze Square.[42]

Beyond Grodzka Gate spread Podzamcze District with a synagogue, surrounded mainly by wooden buildings overlooked by Castle Hill. The Royal Castle occupied a larger area than the monumental structure now crowning the Hill. Far from

[37] APL, Księga m. Lublina [The Book of Lublin Town for 1573–1578], Opis pożaru miasta przez Sebastiana Klonowica, ówczesnego pisarza rady miejskiej. Lublin 7 V 1575 [The Fire of the Town Described by Sebastian Klonowic, Then Penman of the Town Council. Lublin 7 May 1575], fols 253–54v, translated from Latin by S. Paulow; H. Gawarecki, S. Paulowa, M. Stankowa, 'Klęski pożarów w Lublinie', *Rocznik Lubelski*, vol. 16 (1973), pp. 211–25.

[38] APL, AmL, Przywilej króla Zygmunta III Wazy z dnia 31 marca 1604 roku [The Privilege of King Sigismund III Vasa], ref. no. 131.

[39] A high-resolution digital elevation model (with a spatial resolution of 1 m and higher) is made available to the public free of charge by the Head Office of Geodesy and Cartography (GUGiK) in accordance with the amendment of the Geodetic and Cartographic Law of 31 July 2020, https://www.geoportal.gov.pl/en/data/digital-elevation-model-dem/; J. Butrym, M. Harasimiuk, A. Henkiel, *Szczegółowa mapa geologiczna Polski 1:50,000. Arkusz 749: Lublin* (Warszawa: Instytut Geologiczny, 1980); M. Harasimuk, A. Henkiel, *Objaśnienia do szczegółowej mapy geologicznej Polski 1:50,000*, fol: *Lublin (749)* (Warszawa: Instytut Geologiczny, 1982).

[40] Jakimińska, 'Złoty wiek Lublina', p. 65; Patronowicz, 'Socjotopografia późnośredniowiecznego Lublina'.

[41] Jakimińska, 'Złoty wiek Lublina', p. 77.

[42] K. Mucha, 'Cyfrowa rekonstrukcja kościoła farnego pw. św. Michała Archanioła', https://teatrnn.pl/rozwoj-przestrzenny/cyfrowa-rekonstrukcja-kosciola-farnego-pw-sw-michala-archaniola/, (accessed on 13 May 2024).

being a monolith, the Castle comprised representative and logistical structures. This complex of buildings encompassed the King's townhouse, fortified towers, an entrance gate, a chapel, stables, a water well, and servant quarters.[43]

b) Krakowskie Przedmieście

The Cracow Gate served as the main exit from the town and consisted of the main gate, the foregate, and the entrance part, i.e. the Barbican. The Barbican and the Foregate were connected by a drawbridge, allowing passage across a dry moat. At that time, a square had emerged at Cracow Gate, from which two thoroughfares branched out: Marii Panny and Krakowskie Przedmieście.[44] Marii Panny Street ran along present-day Kozia and Narutowicza Streets. To its right stood buildings that reached Krakowskie Przedmieście, while its left side was unoccupied to prevent fire from spreading from the suburbs to the walled city. Further on, there was a gutter, Żmigród manor houses, Bernardyńska Street, the Church of the Conversion of St Peter with a cemetery and monastery, and, further on, manors and the Church of Our Lady of Victory with cloister houses for sisters and monks of the Brigdettine Order.[45] The monastic complex had strategic importance. Enclosed by a wall, it served as the southern bastion of the Krakowskie Przedmieście fortification system.[46] The monastery's vicinity housed the vital elements of the Old Polish town water supply system: the *rurmus* (water pump) building and the water tower incorporated into the wall surrounding the monastic gardens.

Krakowskie Przedmieście Street was the most prominent suburban roadway. A hospital with a cemetery was situated to its right, and the next building was the Church of the Holy Spirit. Świętoduska Street, with its gardens and manors, started behind the church, along with an exit into present-day Zielona Street. Compact buildings lined the right side of Krakowskie Przedmieście, mainly wooden houses on stone foundations and farm buildings. The left of Krakowskie Przedmieście was occupied by brick and brick-and-timber houses owned by the suburban burghers and manors of wealthy noblemen. At the time, present-day Staszica and Kapucyńska Streets outlined the borders of the urbanised area. Earthen walls marked the boundary of the compact suburb. Sturdier walls and fences formed parts of this border, wherever they surrounded manor and monastic buildings. Manor settlements (often surrounded by walls), church demesnes, and land owned by the gentry or town authorities were scattered beyond the line of fortifications.

The defence system of the suburb had several focal points. One was the monastic complex of the Church of Our Always Victorious Lady. Other defensive points were the mansions in present-day Litewski Square and the area that became the Carmelite convent on present-day Staszica Street. A pottery workshop was situated outside of the western line of fortifications, near the present-day intersection of Krakowskie Przedmieście and Hugo Kołłątaj Streets. Further along the Wielkopolski Tract stood the Dominican Church of the Holy Cross (currently the university church of the Catholic University of Lublin) and the town gallows (so-called Hangman's House). The cartographic

[43] S. Wojciechowski, W. Szczawiński, 'Lublin circa 1570 [map]', in S. Wojciechowski, *Województwo lubelskie w drugiej połowie XVI wieku* (Warszawa: PAN Instytut Historii, 1966); id., 'Renesansowy zamek lubelski', *Ochrona Zabytków*, vol. 7, no. 3 (1954), pp. 178–82.

[44] APL, AmL, Rejestry dochodów, wydatków, podatkowe, Rejestr podatków, kontrybucji zwanych szos [zbieranych] podczas interregnum autoritetu generalnej konfederacji warszawskiej i partykularnej lubelskiej, według konstytucji sejmu generalnego lubelskiego z roku 1569, ref. no. 267.

[45] R. Niedźwiadek, 'Kościół pobrygidkowski pw. Wniebowzięcia Najświętszej Marii Panny Zwycięskiej w Lublinie', in *Kościoły i klasztory Lublina*, pp. 46–73.

[46] J. Teodorowicz-Czerepińska, G. Michalska, *Mury miejskie Lublina* (Lublin: UM Lublin 2021).

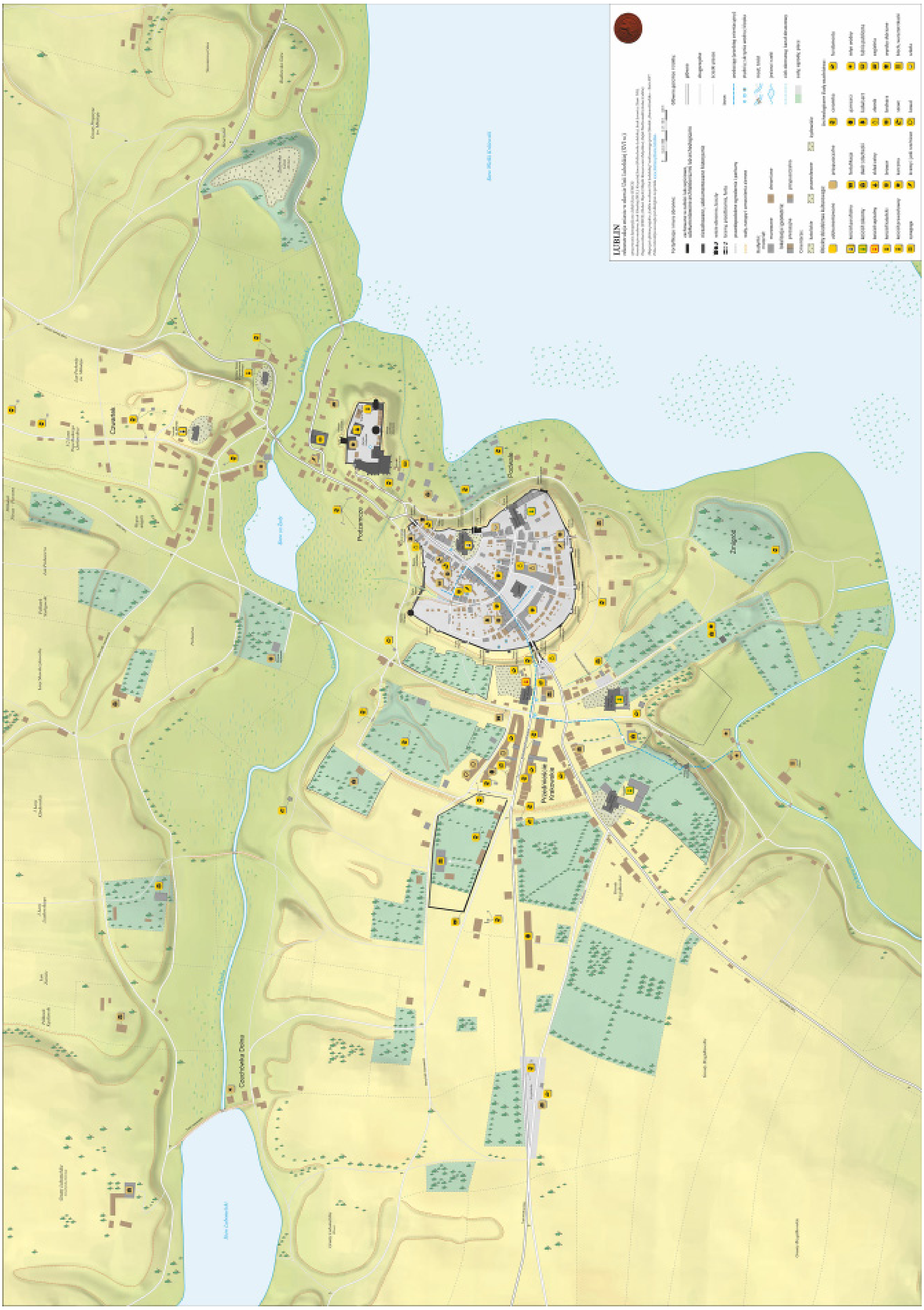

Fig. 6. J. Kuna et al., Lublin: rekonstrukcja miasta w okresie Unii Lubelskiej [map], scale of 1:3,000, OBGTNN, Lublin 2019, 14% of original size. Map legend details have been presented in Figure 9. Interactive map available at www.teatrnn.pl/miejsca/mapa/unia-lubelska (accessed on 7 Nov. 2019)

study does not cover these two sixteenth-century structures.[47]

c) Manors and demesnes

The southern suburb comprised a complex of Bernardine monastic properties and numerous manor buildings with gardens on both sides of the road, corresponding to present-day Bernardyńska Street. Further on lies one of the oldest Lublin settlement areas, a separate hill called Żmigród. In the first half of the sixteenth century, the Żmigród settlement was destroyed. It was not until the Union of Lublin that noblemen and magnates started redeveloping the hill with their residences.[48]

The Czechówka River flowing through the Podzamcze, with its meandering riverbed and numerous backwaters and ponds, separated the Old Town and Castle hills from the Czechow and Czwartek suburbs. Czwartek was a *jurydyka* (a settlement outside the walls of a royal town and independent of the municipal laws but under the jurisdiction of its secular or ecclesiastical owner) with a small market square and wooden low-rise buildings overlooked by the brick St Nicholas Church.[49]

The area between present-day Czechów and Słomiany Market was occupied by demesnes and farmland, as well as village buildings and manors, some of which played the role of defensive structures. The map does not include a crossing of the Bystrzyca River to the east of Słomiany Market, which existed at the time. Further on stood Budzyń Inn.[50]

d) Hydrographic network

Sixteenth-century Lublin was nestled between two rivers: Bystrzyca and Czechówka. From the fourteenth century onwards, the energy of these rivers was used to impound ponds.[51] The Bystrzyca, the Skrzyniczka (Czerniejówka), and the Czechówka flowed into the Great Royal Pond (Fig. 7). With a length of 2.5 km, width of up to 1 km, and a surface area exceeding 130 ha, the Great Royal Pond formed the largest body of water near the town. The reservoir filled the floodplain of Bystrzyca Valley: from the influx of the Skrzyniczka (present-day Czerniejówka) River. It continued to the northeast, i.e., towards the levee and the mill complex in the Tatary Village. This artificial water reservoir had been created to power four mills (including a paper mill). In the sixteenth

[47] R. Niedźwiadek, J. Tkaczyk, 'Odkrycia archeologiczne poprzedzające remont poczty w Lublinie', in *Budynek Poczty Głównej w Lublinie*, ed. Z. Nestorowicz (Lublin: Poczta Polska, 2007), pp. 7–32; R. Niedźwiadek, 'Cztery zespoły kafli lubelskich z okresu od początku XVI do połowy XVII w.', in *Średniowieczne i nowożytne kafle. Regionalizmy – podobieństwa – różnice*, red. M. Dąbrowska, M. Karwowska (Białystok: Muzeum Podlaskie w Białymstoku, 2007), pp. 87–99; R. Niedźwiadek, J. Tkaczyk, 'Warsztat garncarski z przełomu średniowiecza i okresu staropolskiego, odkryty na tyłach budynku Poczty Głównej w Lublinie (ul. Krakowskie Przedmieście 50), typescript at the Archive of the Wojewódzki Urząd Ochrony Zabytków in Lublin, ref. no. 19009 (Lublin, 2011); H. Gmiterek, 'Lublin jurydyk i Trybunału Koronnego', in *Lublin. 700 lat*, p. 87.

[48] K. Janus, 'Przekształcenia urbanistyczno-architektoniczne przedmieścia za bernardynami w Lublinie od średniowiecza do schyłku XIX wieku', PhD thesis, Faculty of Architecture, Warsaw University of Technology (Warsaw, 2018).

[49] J. Chachaj, 'Rozwój struktur parafialnych na obszarze Lublina do połowy lat 70. XX wieku', in *Lublin. Historia dzielnic*, pp. 7–22; H. Mącik, 'Kościół św. Mikołaja na Czwartku w XVI i początkach XVII wieku oraz jego kontekst urbanistyczny', in *Lublin. Historia dzielnic*, pp. 346–50.

[50] *Lustracja województwa lubelskiego*, p. 34.

[51] Numerous cartographic materials document the Great Royal Pond, which is also extensively discussed in geographical science literature. Founded under the rule of Kazimierz III the Great, the pond formed part of Lublin's urban landscape for nearly 500 years. The continuous influx of river sediment from the fertile Giełczew Uplands caused the Great Royal Pond to become silted, overgrown and reduced in size. By the nineteenth century, the pond had already been reduced to a residual water body. Up to the 1930s, further sections of the muddy valley were reclaimed. See Kociuba, *Lublin. Rozwój przestrzenny i funkcjonalny*, pp. 109–11; ead., 'Rola wód powierzchniowych w rozwoju Lublina', *Annales Universitatis Mariae Curie-Sklodowska – Polonia*, Sectio B, vol. 74 (2019), pp. 8–11; ead., 'Rekonstrukcja sieci rzecznej Lublina w XVI wieku', http://teatrnn.pl/leksykon/artykuly/rekonstrukcja-sieci-rzecznej-lublina-w-xvi-wieku/ (accessed on 8 Jan. 2025); P. Mroczek, J. Rodzoś, 'Środowisko przyrodnicze Kalinowszczyzny i Ponikwody', in *Lublin. Historia* dzielnic, pp. 3–6; K. Szafranek, 'Wielki Staw Królewski – zapomniana oczywistość', https://teatrnn.pl/leksykon/artykuly/wielki-staw-krolewski-zapomniana-oczywistosc/ (accessed on 26 Sep. 2024).

century, it covered a surface area of about 130 ha. It also served as a retention basin and was used for fishing. The Tatary, Bronowice, Danów and Dziesiąta Villages were spread along the eastern banks of the Great Royal Pond.[52] The map also shows the recreated final section of the pipe ditch (about 4.8 km from the narrowing of the Bystrzyca valley below the pond levee in the village of Wrotków), which powered the water supply facilities and the town mill.[53]

The sixteenth century saw the impoundment of an approximately two-hectare Za Żydy Pond on the Czechówka River within town borders. Close by the town, near the border with the village of Czechów, there was a slightly larger, approximately eight-hectare pond named after its owners, the Lubomelski family. These ponds powered mills, while two important transport and trade routes passed along the dykes, connecting Lublin with Lithuania-Ruthenia and Mazovia (Warsaw). In the second half of the fifteenth century, the Grodzianka River witnessed the drying of its source, a slope-foot spring in the vicinity of Grodzka Gate. Thus, in the analysed period, the watercourse was overgrown with vegetation. By the sixteenth century, the pond "under the castle" (located below Kowalska Street) had ceased to exist, leaving wetlands fed by discharges from the town gutter.[54]

e) Reconstruction-related problems and uncertainties

When recreating map content, the authors encountered ambiguities and divergent interpretations of research results, which sparked expert discussions. Roadway recreation proved the most challenging, as transport routes are complex landscape elements to reconstruct.[55] Archaeologists have discovered and documented remnants of central road infrastructure such as wooden musts (plank roads) or cobblestones. Beyond main thoroughfares, however, roads were not mainly regulated. More distant sections were often shifting dirt tracts, which were affected by the seasons. Geomorphological research paves the way for assuming that some sixteenth-century transport links passed through gullies, causing their constant deepening.[56] Owing to the scarcity of historical and archaeological data, we mapped minor routes by adjusting them to the terrain presented in the eighteenth-century maps by Stanisław Łęcki and Johann Tretter.

Another problem emerged when the authors attempted to recreate the Great Royal Pond and determine the location of related facilities (water and paper mills) and crossings. Elevation analyses of contemporary Digital Elevation Model data formed the basis for identifying potential furthermost edges of the pond. Using GIS tools, the authors simulated the flooding

[52] APL, AmL, Lustracje Miasta Lublina i Województwa Lubelskiego, Lustracja miasta Lublina z 1570 roku, ref. no. 310, ff. 23; Kociuba, *Lublin. Rozwój przestrzenny i funkcjonalny*, p. 103, fig. 8; ead., 'Rola wód powierzchniowych', pp. 8–11, Fig. 2 at p. 9; ead., 'Rekonstrukcja sieci rzecznej Lublina'.

[53] D. Kociuba, 'Przyrodnicze, gospodarcze i polityczne uwarunkowania rozwoju struktury funkcjonalno-przestrzennej Lublina', PhD thesis, Faculty of Earth Sciences and Spatial Management, Maria Curie-Skłodowska University in Lublin, 2005; ead., *Lublin. Rozwój przestrzenny i funkcjonalny*, p. 103, fig. 8, pp. 109–113; ead., 'Rola wód powierzchniowych', pp. 8–11; ead., 'Rekonstrukcja sieci rzecznej Lublina'.

[54] Kociuba, *Lublin. Rozwój przestrzenny i funkcjonalny*, pp. 110–11; ead., 'Rola wód powierzchniowych', pp. 9–11, Fig. 2 at p. 9; ead., 'Rekonstrukcja sieci rzecznej Lublina'.

[55] M. Zawadzki, 'Sources and methods of reconstruction of postal roads in the second half of the eighteenth century on the example of the former Lublin Voivodship', *Polish Cartographical Review*, vol. 50, no. 4 (2018), pp. 233–42.

[56] D. Kociuba, *Lublin. Rozwój przestrzenny i funkcjonalny*, pp. 138–39; ead., 'Rekonstrukcja sieci drogowej Lublina w XVI wieku', http://teatrnn.pl/leksykon/artykuly/rekonstrukcja-sieci-drogowej-lublina-w-xvi-wieku/ (accessed on 8 Jan. 2025). Cf. J. Rodzik, 'Wąwozy a suche doliny erozyjno-denudacyjne w Lublinie', in *Wąwozy i suche doliny Lublina: potencjał i zagrożenia*, ed. E. Trzaskowska (Lublin: UM Lublin, 2014), pp. 21–30; J. Superson, J. Reder, P. Demczuk, 'Regionalne uwarunkowania rozwoju rzeźby terenu Lublina', *Annales Universitatis Mariae Curie-Sklodowska*, Sectio B, vol. 73 (2018), pp. 107–24; W. Zgłobicki, J. Rodzik, J. Superson, M. Dotterweich, A. Schmitt, 'Phases of gully erosion in the Lublin Upland and Roztocze region', *Annales Universitatis Mariae Curie-Sklodowska*, Sectio B, vol. 69, no. 1 (2014), pp. 149–62.

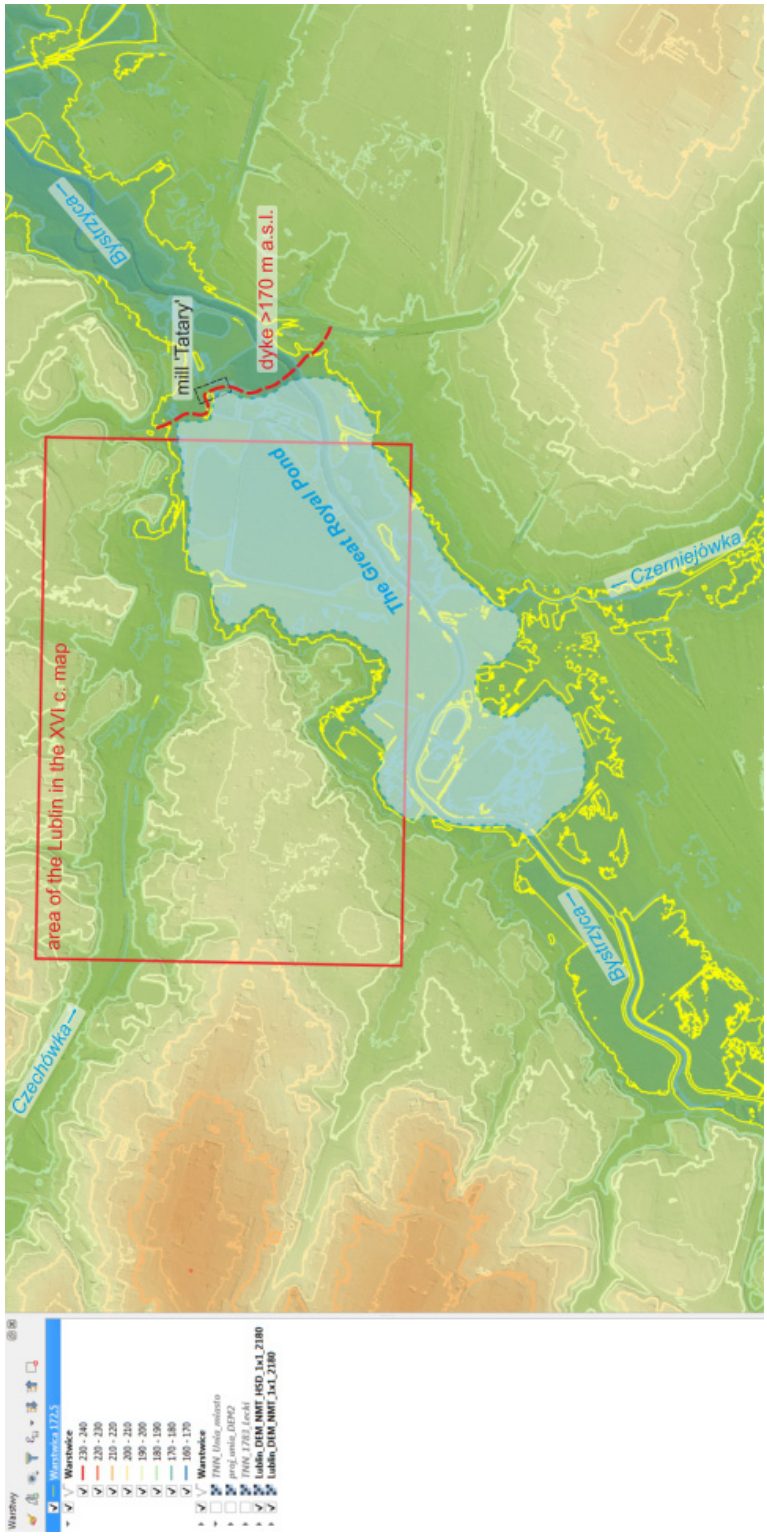

Fig. 7. The probable extent of the Great Royal Pond was determined based on archival maps, the Detailed Geological Map 1:50,000 and analyses of the modern Digital Elevation Model. Inundation of the area up to an elevation of 170 m above sea level (the elevation of the area around the 'Tatary' mill complex) was simulated. The yellow line shows the level of 172.5 m above sea level, defining the maximum present extent of the floodplain and wetland in the Bystrzyca Valley. A compilation of archival maps from the 18th to 19th centuries documents the reservoir area's gradual silting up and shrinking. Regulation of the Bystrzyca riverbed was carried out in the 1920s and 1930s. To this day, most of the area is still wetland. Compiled by J. Kuna

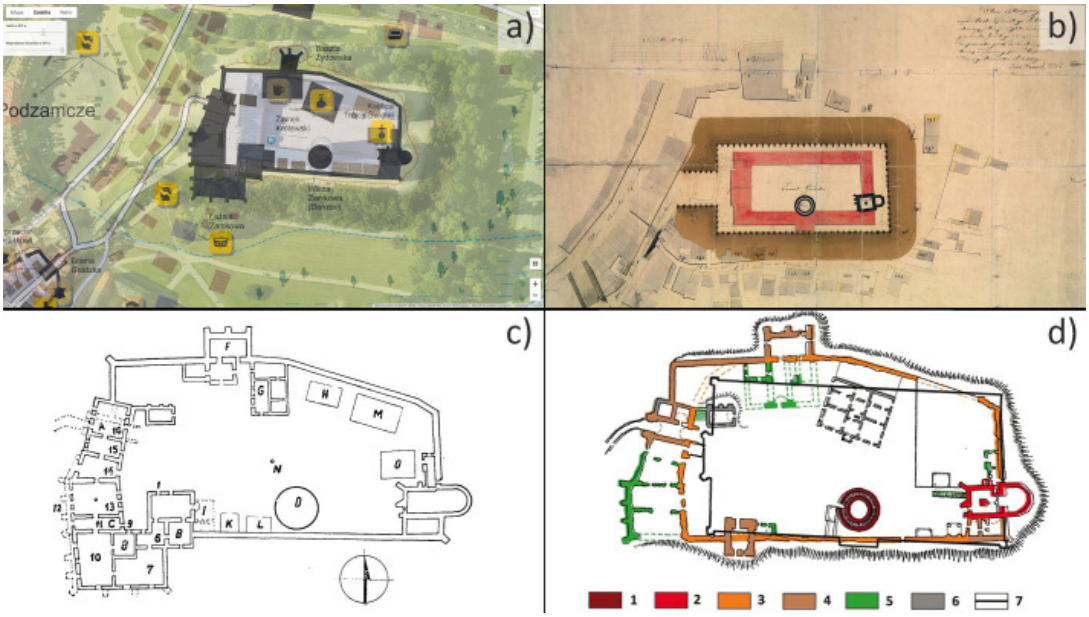

Fig. 8. The Royal Castle in Lublin: (a) view presented at www.teatrnn.pl/miejsca/miejsce/zamek; (b) castle remodelling design by J. Hempel (1825); (c) Renaissance castle recreated by S. Wojciechowski (1954); (d) chronological castle layering by J. Teodorowicz-Czerepinska (1995), supplemented by M. Florek (2015). Layer designations: (1) keep (tower), 13th/14th c.; (2) chapel, 13th/14th c.; (3) castle perimeter walls, first half of the 14th c.; (4) 15th-century fortified towers, walls and buildings; (5) 16th-century buildings and extensions, (6) 18th-century buildings and extensions. The portal has marked confirmed and discussable elements using different graphical designations (accessed on 7 Nov. 2019)

of Bystrzyca Valley up to the 170 MASL ordinate, which corresponds to the elevation of the dyke near Tatary Mill. The authors then compared simulation outcomes with the fluvial sediments marked in the Detailed Geological Map of Poland, which is set at a scale of 1:50,000 (sheet 749: Lublin).[57] The engraving by Frans Hogenberg and Georg Braun illustrates boats ferrying between Podwale and the opposite bank of the pond. The 1661 inspection of Lublin mentions a crossing at Danów, which did not survive today. It was likely located near what was to become the southern suburb called Piaski alias Kazimierz. Unfortunately, sources dating back to the Union of Lublin fail to mention the exact location of the crossing. For this reason, the crossing has not been included in the map.

Lublin inspections mention manors existing in the Lublin Union period, but subsequent documents are inconsistent. The 1565 inspection lists 12 manors, the 1570 document records 19 such buildings, while a 1573 *schoss* (tax) register mentions 11 manors. As manor descriptions and locations failed to provide sufficient clarity, the authors mapped 11 manors whose sixteenth-century existence was confirmed by WUOZ studies.

The 1565 and 1570 inspections mention castle pipes, i.e. the system for supplying water to the Royal Castle from Za Żydy Pond. However, providing even a schematic outline of the castle pipes proved infeasible, as neither precise information on the pipe course nor technical data on how

[57] Butrym, Harasimiuk, Henkiel, *Szczegółowa Mapa Geologiczna Polski 1:50.000*; Harasimuk, Henkiel, *Objaśnienia do szczegółowej mapy geologicznej*.

Castle Hill was supplied with water were available. Recreating the shape of Lublin Castle itself also proved problematic (Fig. 8). Jacob Hempel's 1825 plan, created for castle remodelling, outlines palace buildings to the south, up to the present-day wall of the Lublin Museum. Frans Hogenberg and Georg Braun depict castle buildings differently in their panorama, where individual palace facilities do not form a straight line. Stefan Wojciechowski argued that the south wing of the palace protruded well beyond the present-day external outline of Castle Hill.[58] In the eighteenth century, the slopes of Castle Hill had been levelled and occupied by the Podzamecka Jurydyka. The authors decided to present a more elaborate structure on their map of the town in the Lublin Union period, whereby they clarified which royal residence elements stemmed from the plan by Jakub Hempel and which from the scientific study by Stefan Wojciechowski. It is worth adding that recreating many fragments of the town walls was also troublesome. Current knowledge is incomplete, as frequent renovations of tenement houses absorbed some wall sections, while other segments have yet to be subjected to research.[59] We have presented a summary of all mapped objects in Table 4.

5. Editing the map of Lublin in the Lublin Union period

The interactive map of sixteenth-century Lublin was designed with vector and raster graphic tools. The area subjected to detailed cartographic recreation corresponds to a 4,020 × 2,850 m rectangle and covers about 11.5 km^2, which equals less than 8 per cent of present-day Lublin's strict centre. At the same time, the analysed area is more than sixty times larger than the "town within the walls" and far exceeds previous scientific papers with a similar level of detail.[60] The master map presents an area determined by the layout of sixteenth-century settlement remnants identified in archaeological studies and WUOZ documentation.

The map is set at a scale of 1:3,000, i.e. it is sufficiently large to contain all the situational details of the recreated objects yet small enough for its entirety to fit into an A1-size sheet of paper. The map scale resembles the oldest surviving Lublin maps, i.e. 1:2,500–1:5,000.[61] However, this map provides more cartometricity and detail than the old plans. Map georeferencing is consistent with contemporary geodetic studies, aerial photographs, satellite images and the BDOT 10k database. When designing thematic map symbols, our guiding principle was to ensure their legibility and ease of association (character isomorphism). As a result, the small, simplified pictograms are explicit references to the appearance or the function of represented objects.[62] The map legend (Fig. 9) lists 86 object categories, including 26 symbols related to cultural heritage sites and archaeological traces of settlements. To signify their reliability, the authors adopted two colour variants for all fortification and building elements and thematic designations. The background (shield) colours listed below denote the following:

– yellow (CMYK: 0%, 20%, 100%, 0%) – particular, precise – i.e. surviving in whole or in part, confirmed by architectural or archaeological research,

[58] Wojciechowski, 'Renesansowy zamek lubelski', pp. 178–79.

[59] H. Gawarecki, 'Mury obronne Miasta Lublina', *Ochrona Zabytków*, vol. 7, no. 3 (1954), pp. 170–77; J. Tkaczyk, 'Fortyfikacje miejskie Lublina w badaniach archeologicznych', in *Fortyfikacje Lubelszczyzny. Badania archeologiczne*, ed. E. Banasiewicz-Szykuła (Lublin: Wojewódzki Urząd Ochrony Zabytków, 2017), pp. 11–46.

[60] H. Gawarecki, C. Gawdzik, *Lublin* (Warszawa: Wydawnictwo Arkady, 1959); Wojciechowski, *Województwo lubelskie w drugiej połowie XVI wieku.*

[61] Cf. Chap. 3c.

[62] L. Ratajski, *Metodyka kartografii społeczno-gospodarczej* (Warszawa: Państwowe Przedsiębiorstwo Wydawnictw Kartograficznych, 1973); *Wprowadzenie do kartografii i topografii*, ed. J. Pasławski (Warszawa: Nowa Era, 2006); K.A. Saliszczew, *Kartografia ogólna* (Warszawa: PWN, 1998); A. Głażewski, K. Kałamucki, P. Kowalski, M. Stankiewicz, *Podstawy wizualizacji kartograficznej* (Lublin: Wydawnictwo UMCS, 2015), pp. 60–61, 68–69.

Fig. 9. Lublin: Reconstruction of Lublin in the Lublin Union Period, map legend, 72% of the original size. Symbol model composition clearly distinguishes confirmed (in situ) and unconfirmed objects (present in descriptive, cartographic and iconographic sources). Compiled by J. Kuna (2019)

– beige (CMYK: 0%, 15%, 60%, 20%) – presumed, vague – i.e. not surviving to date, documented in written sources, iconography or old maps.

The map style is modern and refers to contemporary topographic and landscape maps, although some content is inspired by the design of old topographic maps and plans of Lublin. To improve map legibility and figure-ground organisation, the authors designed their modifications to the LiDAR and SRTM 30m Digital Elevation Models, which enabled applying hypsometry and terrain shading.

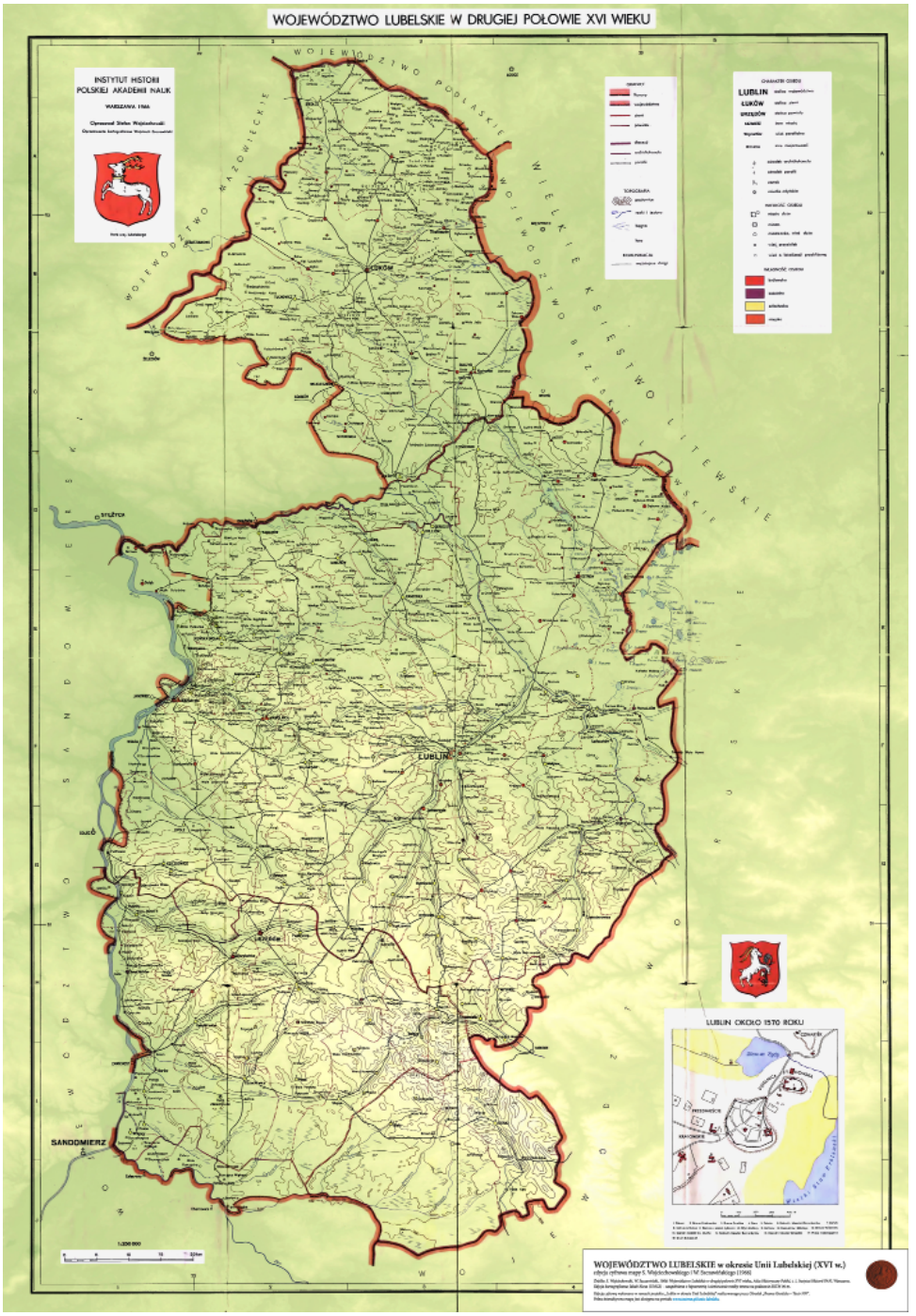

Fig. 10. Województwo lubelskie w drugiej połowie XVI wieku, scale of 1:250,000, 42% of original size. After: Atlas historyczny Polski. Województwo lubelskie w drugiej połowie XVI wieku, *ed. W. Pałucki, prep. S. Wojciechowski, cart. prep. W. Szczawiński (Warszawa: Państwowe Wydawnictwo Naukowe, 1966). Digital modification by J. Kuna (2019)*

The compiled map was exported to a TIF file, with approximate dimensions and size of 20,000 x 14,000 pixels and about 0.8 GB, respectively. Next, the map was tiled in line with the XYZ Open Geospatial Consortium protocol standard (EPSG: 3857). Raster overlay use is analogous to standard WMTS (Web Map Tiled Service) but is displayed in Google Maps API through a *Javascript* website code. Dynamic transparency adjustment (e.g. using a slider) is a vital map feature, as it enables one to visually compare the overlay image with a contemporary map or satellite base.

To present the recreated town in a broader spatial context, the authors decided to enrich the interactive map with additional historical background, i.e. a digital modification of the 1:250,000 map of the sixteenth-century Lubelskie Voivodeship by Stefan Wojciechowski (1966).[63] This addition allows for presenting sixteenth-century Lublin and its vicinity against the backdrop of the present-day agglomeration, as well as other regional and voivodeship towns (Fig. 10). Publishing OGC raster underlays enables implementing the map into other websites or desktop GIS programs.[64]

6. Conclusion

The interactive map of Lublin in the Lublin Union period (http://teatrnn.pl/unia-lubelska/) is the first project to provide such a detailed recreation of this town by compiling the outcomes of in-depth archaeological, architectural, historical, and geographical research. It is a pioneering attempt to synthesise the state of play in research on sixteenth-century Lublin. Drawing up a map of the urban layout of sixteenth-century Lublin was a demanding research task. The lack of original cartographic maps from the analysed period posed the main difficulty, as it necessitated recreating the urban landscape primarily based on non-cartographic materials: written sources, engravings, and conservation documentation. Employing geographic information systems and vector graphic tools to model the spatial layout of sixteenth-century Lublin enabled gathering documents on a single platform and subjecting them to ongoing verification during expert discussions. More than 20 meetings resulted in designing successive, increasingly accurate iterations of the map (five versions with significant changes, excluding minor adjustments).

The overarching objective behind developing a multimedia map of Lublin in the Lublin Union period was to promote the town's past and cultural heritage. The discussion of findings concerning the course and location of the elements forming part of sixteenth-century Lublin corresponds to the order of cartographic recreation of individual map components. The authors presented anthropogenic content, i.e. fortifications, buildings, and the road network. The research team recreated environmental elements, i.e. the river network and terrain.[65] The study also focused on cultural heritage, i.e. local geographical names and thematic objects representing traces of human economic activity. Adopting this order ensured the correct recreation sequence. The authors started developing the spatial model (GIS database) with the 'hard' data identified in many source types, as these supplied precise locations. The authors used many research methods to cross-validate these data (Table 4). 'Hard' data analysis was

[63] Wojciechowski, *Województwo lubelskie w drugiej połowie XVI wieku.*

[64] Https-encrypted XYZ tiles are available at 1) sixteenth-century Lublin map: teatrnn.pl/files/places/overlays/lublin-xviw/{z}/{x}/{y}.png, 2) Lublin Voivodeship: teatrnn.pl/files/places/overlays/lubelskie-xviw/{z}/{x}/{y}.png.

[65] M. Boruch, M. Bevz, R. Chyżewska, J. Myśliwiec, 'Rola dolin i wąwozów jako naturalnych granic linii fortyfikacyjnych w kształtowaniu struktury urbanistycznej miasta Lublina', in *Wąwozy i suche doliny Lublina*, pp. 32–39; A. Rozwałka, 'Tereny rynku miasta Lublina w okresie średniowiecza i w czasach wczesnonowożytnych. Archeologiczny szkic do portretu stratygraficznego', *Raport*, no. 12 (2017), pp. 147–67.

followed by inputting highly reliable data from several sources yet providing only an approximate location or course. Finally, the authors introduced uncertain and imprecise data characterised by conceptual or factual vagueness, e.g. data found only in descriptive sources. Documenting vague and uncertain phenomena entails additional methodological challenges owing to the exact and off-scale nature of GIS.[66]

Processing the database into an interactive map and designing a modern cartographic base helps ensure the correct perception of the situational and landscape elements. The thematic objects are marked with interactive geometries and legible symbols. The accumulated source base clarifies the depicted objects. It adds to the narrative so that Readers can learn what is (was) situated in a particular place, what it (might have) looked like, what is known about it and where this knowledge comes from. Regarding its functionality, the map is a GUI (graphical user interface), i.e., a graphical interface for spatial database users containing conservation documentation. The map, therefore, makes an excellent tool for studying Lublin's spatial layout during the analysed period and conducting other aspects of cultural heritage research. Relational links between places and references to documentary sources, individuals and events provide opportunities for further analyses, e.g. assist in determining the functions of different parts of the sixteenth-century town, its sociotopography or family relationships between the burghers.

Drawing up a map of Lublin in the Lublin Union period required synthesising singular facts into a coherent model of sixteenth-century reality. The project would not have emerged were it not for the bold notion to provide Readers with a legible map with structures whose presence in sixteenth-century Lublin has been confirmed and accurately determined but also with objects whose location is uncertain and with elements only mentioned in perfunctory descriptions. It is the conviction of the authors that the map of Lublin in the Lublin Union period is a scientific hypothesis. Indeed, the current map is not devoid of inaccuracies. In the five years following project completion and map publication, archaeological supervision and research have contributed to the verification of several objects classified as discussable in our interactive map of Lublin in the Lublin Union period.[67] Nevertheless, the map remains a valid and concrete point of reference for polemics in the scientific community of Lublin and for defining further research directions. ■

[66] M. Krukowski, *Nieostrość w modelowaniu kartograficznym* (Lublin: Wydawnictwo UMCS, 2021); id., 'Niepewność w kartografii historycznej', in *Człowiek twórcą historii*, ed. C. Kuklo, W. Walczak, vol. 6 (Białystok: Uniwersytet w Białymstoku, 2024), pp. 237–58; A. Schumacher, M. Słomski, D. Stracke, 'Uncertain information and spatial objects', in *Modelling the City: Formal Ontology and Spatial Humanities*, ed. W. Duży (Routledge, 2024), pp. 100–29.

[67] Cf. Popular academic symposium 'Re-evolutions of Lublin: The Town and its Suburbs', 28 May 2024, Lublin.

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Wyzwania związane z rekonstrukcją historycznego krajobrazu miejskiego Lublina w okresie unii lubelskiej (1569) na mapie interaktywnej

Streszczenie

Lublin w okresie Unii Lubelskiej (1569) to tytuł interdyscyplinarnego projektu badawczego realizowanego przez Ośrodek Brama Grodzka – Teatr NN w Lublinie w ramach obchodów jubileuszu 450. rocznicy podpisania aktu unii polsko-litewskiej. Ideą projektu było opracowanie portalu internetowego (https://teatrnn.pl/unia-lubelska/) przybliżającego tytułowe wydarzenie w nowoczesnej, atrakcyjnej formie. Digitalizacja dokumentów archiwalnych, krytyczne edycje źródeł, katalogi zabytków archeologicznych, bazy danych, mapy interaktywne, wizualizacje i animacje komputerowe, materiały wideo, ebooki – to przykładowe multimedia mające wprowadzić czytelnika w wirtualny świat XVI-wiecznego Lublina. Jednym z kluczowych zadań projektu było opracowanie interaktywnej mapy Lublina okresu unii lubelskiej: mapy z jednej strony syntetyzującej stan wiedzy na temat przestrzeni miasta XVI w., a z drugiej – stanowiącej uniwersalny interfejs do nawigacji po zgromadzonych zbiorach materiałów, dokumentów i opracowań poświęconych miastu i jego mieszkańcom. Proces opracowania mapy Lublina epoki unii lubelskiej miał charakter dyskusji eksperckiej. W toku konfrontacji perspektyw badawczych archeologa, architekta, geografa, historyka, historyka sztuki i kartografa przeanalizowano 6 dużych zbiorów źródeł pisanych, 11 dużych i kilkadziesiąt pomniejszych map i planów, blisko 150 pozycji dokumentacji archeologicznej i architektonicznej oraz kilkadziesiąt pozycji literatury. Do prac badawczych wykorzystano programy GIS. Metodą retrogresywną, stosując szeregi map pośrednich, wykonano georeferencję materiałów kartograficznych. Zwektoryzowano geometrie obiektów z map, projektów architektonicznych, dokumentacji konserwatorskiej i nadzorów archeologicznych. Szczególną uwagę poświęcono reliktom fortyfikacji miejskich, umocnionych klasztorów i dworów oraz wodociągu staropolskiego. W GIS udokumentowano ponad 380 obiektów o XVI-wiecznej (lub starszej) metryce, zaprojektowano szablon mapy wynikowej i przygotowano warstwy tematyczne do profesjonalnej redakcji kartograficznej. Opracowanie mapy układu urbanistycznego Lublina w XVI stuleciu było trudnym zadaniem badawczym. Główną przeszkodą był brak oryginalnych opracowań kartograficznych z epoki. Retrogresja ponad 200 lat przemian, w burzliwym okresie dziejów, wykonana głównie na podstawie niekartograficznych źródeł informacji (źródeł pisanych, rycin, dokumentacji konserwatorskiej) była obarczona dużym

ryzykiem błędu. Zaangażowanie interdyscyplinarnego zespołu badawczego oraz nowoczesnych narzędzi zaowocowało opracowaniem modelu rzeczywistości, który z jednej strony jest zgodny z najnowszym stanem wiedzy na temat miasta w badanym okresie, a z drugiej – w poglądowej formie przybliża naukowe ustalenia niewykwalifikowanemu odbiorcy. ■

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