Bulletin of Geography. Socio–economic Series / No. 31 (2016): 73–86

ISSN 1732–4254 quarterly

BULLETIN OF GEOGRAPHY. SOCIO–ECONOMIC SERIES
journal homepages:
http://www.bulletinofgeography.umk.pl/
http://wydawnictwoumk.pl/czasopisma/index.php/BGSS/index
http://www.degruyter.com/view/j/bog

From village to city through maps: historical cartographic materials as an information source on 20th century environmental changes due to urbanisation in Poland

Kamil Nieścioruk[CDFMR]

University of Life Sciences in Lublin, Department of Environment Engineering and Geodesy, Leszczyńskiego 7, 20-069 Lublin, Poland; phone: +48 815 248 123, e-mail: kamil.niescioruk@up.lublin.pl; www: www.niescioruk.ppa.pl

How to cite:
Nieścioruk, K., 2016: From village to city through maps: historical cartographic materials as an information source on 20th century environmental changes due to urbanisation in Poland In: Szymańska, D. and Rogatka, K. editors, *Bulletin of Geography. Socio-economic Series,* No. 31, Toruń: Nicolaus Copernicus University, pp. 73–86. DOI: http://dx.doi.org/10.1515/bog-2016-0006

Abstract. The article presents the use of historical Polish post-war topographic maps and their usefulness in the detection and assessment of environmental changes caused by 20th century urbanisation. The case study area is the Polish city of Lublin. Two main research questions are defined and answered. The first is what kinds of maps can be used to trace environmental changes as well as to find the present-day remains of past environments and what is the reliability of these maps? Several series of topographic maps are used here together with aerial photography. The second research question is what changes can be found by comparing spatial sources and what features can be found today with the help of early maps. The main features investigated in this section are linear (road networks) and areal (orchards) supplemented with point features of various kinds (trees, wells, shrines). The quality of cartographic information is assessed and remnants of the past environment are discovered.

Article details:
Received: 23 June 2014
Revised: 18 February 2015
Accepted: 19 October 2015

Key words:
cartography,
GIS,
urbanisation,
environmental changes,
topographic maps.

Contents:

1. Introduction

A map is a medium depicting spatial relations and a particular quality is its ability to present the most recent situation. In the digital era, the life of information is very short and maps are no exception. For example digital products need constant updates to reflect the ever-changing world to secure their position as a leader in a very competitive market. Can early maps be of any interest or value then? Is outdated information stored on paper maps from the 20th century or earlier useful? The answer is 'yes' and the key word is change. Change cannot be analysed with modern, up-to-date data only, a past is needed to compare it with. By knowing both, changes can be traced, causes can be found and solutions or plans can be derived from them. This enriches our knowledge, but can also improve our quality of life, as knowing the past of the place we live in can help us plan its future in a sustainable way and adds a personal touch to our activities by getting us involved with that place.

This paper concentrates on using topographic maps from the second half of the 20th century to analyse changes in the rapidly altered post-war urban environment, what kinds of maps can be used, what the spatial changes caused by urbanization have been and if any of the past environment remains. With a major remodelling of space, demolition of villages and their replacement with blocks of flats, maps are one of the very few sources that can fully illustrate the story. This article aims to give an understanding of this but also show the limitations of the methods.

2. Cartographic sources and cartographic methods in an analysis of past environments – the background

Early maps contain various kinds of historical information presented on many levels and their interpretation depends on the researcher's questions. A comprehensive approach is highly advised as it secures a full understanding of the cartographic material which in many ways is not always precise. However, a shift towards a more precise field of analysis is necessary. For historical geography and history a map is seen as an image of the past, forthe history of cartography it is cartographic heritage or interesting material with aunique geometric quality. No matter what aspects are analysed, maps help to describe, analyse, study and understand natural and human phenomena (Nieścioruk, 2013). The process is known as the cartographic method of research and is widely used in Earth Sciences (Saliszczew, 1998).

While the methodology of using maps has been developed over many years through a group of well-established approaches, the tools have undergone serious changes with an increased use of Geographic Information Systems (GIS). What makes

these tools a step forward is their ease of producing quantitative outcomes. It can be a simple environment change analysis, e.g. of land use, or provide more complicated spatial outcomes as a result of a cartographic method of research. The data help in evaluating the past environments both absolutely and relatively, but also to compare them with the current state through information about qualitative and, most of all, quantitative changes. This is, however, only a numerical presentation, computed much more rapidly but nothing new for cartographers. The important functions of GIS are visualisation and virtualization with even the simplest of 3D models giving a new quality to early maps. A further step is the virtual recreation of a past landscape with both natural and human features based on analyses of early maps supplemented by field work, iconography and textual studies as well as interdisciplinary cooperation.

The use of early maps, the cartographic method of research and GIS tools in environmental change analysis are more broadly described by Nieścioruk (2013).

3. The goal and the subject of the study

Older maps are historical documents and materials showing past spatial relations. The goal of this work is to evaluate what information from post-war materials can be used to recreate a past space from the time just before the intensive spread of urbanisation. In many cities neighbouring areas and villages were destroyed and absorbed into new residential districts. The remains of the past are hard to find nowadays. This article shows how maps (and other cartographic materials) are helpful in searching for these remains and the extent to which it is possible to use maps in analyses of recent environmental changes.

The Rury District in the southwest of the Polish city of Lublin was selected to be the study area. The reason was that after World War II Lublin became the biggest city in eastern Poland and was characterised by rapid development. The population rose from about 80 000 in 1944 (50 000 less than before the war) to over 350 000 today. This has resulted in the need for new residential estates. These changes are still relatively new, so it is fairly easy to observe what remains compared with areas that have been greatly changed by cumulative settlement processes, especially the city centre.

In 1959, the administrative area of Lublin was doubled to over 93 km^2 and one area incorporated included the Rury villages, now forming the Rury district. The name (in Polish 'pipes') comes from the late medieval water supply system. The pipes crossed church and monastic lands hence, later their names were formed using both elements: pipes and the religious order. Rury Wizytkowskie (Visitation Order) was one of a few hamlets that had remained a separate village until the 20th century. Even after its incorporation into the boundaries of Lublin, it was untouched by multi-family blocks of flats. This changed in the late 1970s, when the new residential district and housing cooperative, Czuby, was established. In the planned economy of the People's Republic of Poland such districts were often developed on 'empty' fields ('reserve areas') on the edge of urbanized zones. An entire infrastructure had to be created and it led to construction of residential 'monocultures'. The main goal (and need) was to increase the number of dwelling places and not to develop an efficient living place (with shops, schools, parking places etc) as a part of a city. It was particularly evident in the 70s and the 80s when blocks of flats were constructed using standardized prefabricates (Nowicki, 1991) in areas with no infrastructure. Besides creating infrastructure (roads, power supply etc.), land ownership problems had to be solved, especially when the area was, as in the one analysed, already inhabited. As a consequence, a new spatial system was developed, having nothing or little in common with previous patterns (Kardaś et al., 2014). Closer investigations can however (as shown later in this article) reveal remnants of the past that are not easily noticeable.

The area selected for research is located in the former central and western part of Rury Wizytkowskie, now forming the Ruta 'osiedle' (estate) (established in 1982) and Łęgi (est. 1984). The exact boundary is shown on Fig. 1. It is on a higher area between two dry valleys which have their outlets in the Bystrzyca river valley. The area contains Łęgi and Ruta plus the Widok (southern part) and Błonie (north-western part) estates. Fig. 2 clearly shows the boundary that corresponds to the western and central part of the former Rury Wizytkowskie.

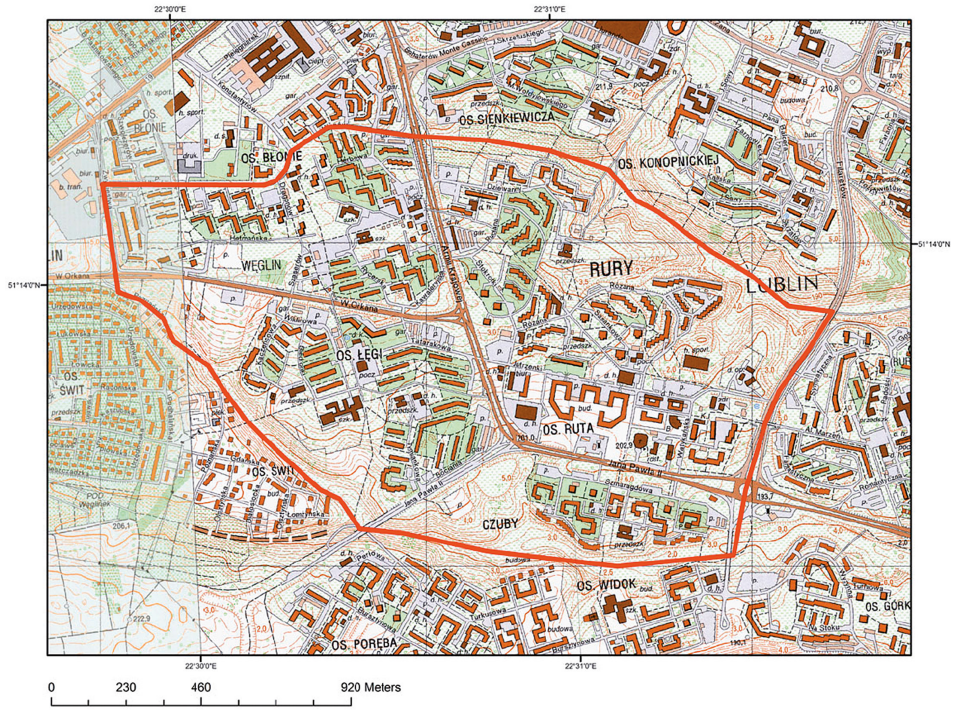

Fig. 1. The research area marked with a red line on a modern topographic map

Source: Author's work using the topographic map ('Układ 1992', M-34-34-A-c-1)

Fig. 2. The research area marked with a red line on a 1970s aerial photograph showing the village of Rury Wizytkowskie

Source: Author's work using archive aerial photography

4. Source materials and their preparation

The delimitation of the research area defines the cartographic materials needed and their territorial extent. The research goals define the scale required for the task as only large scale maps contain information that can answer questions and solve problems.

The spatial source materials used were maps, aerial photography and terrestrial photos.

4.1. Maps

As the rural landscape described in this research disappeared in the late 1970s and early 1980s, archive maps have to be no later than this period. On the other hand, cross-reference materials should be as contemporary as possible: modern topographic maps would be best suited for this task. The selected materials are topographic maps in the '1965' and '1992' coordinate systems.

Large scale (1:25 000 and greater) 20th century maps are limited to the post-war topographic maps produced in the period of the People's Republic of Poland. This brings about serious consequences concerning the accessibility and reliability of sources, and influences the results. The challenge in selecting cartographic materials is the fact of censorship and the various coordinate systems used in post-war Polish cartography (Grygorenko, 1991). For many years the only reliable maps were secret and well-defined system applications were limited to those for military use. A '1942'coordinate system ('układ 1942' in Polish) was used for Warsaw Pact military topographic maps. They were secret, but were used to produce civilian maps of the '1965' system. This system had five projection zones but they did not match at the zonal boundaries: 1:10 000 maps were based on work done on the '1942' system and were used (together with military '1942' 1:25 000) to produce the '1965' 1:25 000 scale maps. The '1965' system was not the oldest post-war civilian mapping series: an older one was the so-called 'obrębówka' based on military maps and was seriously distorted with glue and scissors. It has no topographicor cartographic grid and its quality is very low. The fact of censorship, limited access and falsification of maps in post-war Poland stands as a serious problem in environmental research analyses, as many aspects have to be treated with additional care due to their low reliability in both content and topology. The other side effect of all these limitations is the low trust in maps and their contents among regular users (Konopska, 2011). The situation has started to get better since the political changes of 1989 and one of the steps towards normality was a new coordinate system, called '1992', and used for new topographic maps.

Map sheets selected as cartographic source material were as follows:

— 1:10 000 '1965'system: sheets 136.311 'Lublin' and 136.313 'Lublin-Abramowice',
— 1:10 000 '1992'system: sheets M-34-34-A-c-1 'Lublin-Rury' and M-34-33-B-d-2 'Lublin-Węglin' (used as the cross-reference material in this work),
— 1:25 000 '1965'system: sheets 136.31 'Lublin' and 135.42 'Konopnica'.

The '1992'system is, as mentioned, a reliable one, while the other used here ('1965') is of much worse quality. The question whether it should be used should be addressed, but often there is no other option. The '1965'system covers the whole area of Poland and, in many cases is the only source of information about the 1945-1990 period. The geometric quality of these maps is much lower than for modern maps, but further studies show that a proper georectification justifies using them in research, both as a planimetric and volumetric information source (Nieścioruk, 2014).

4.2. Aerial photography

In the process of recreating a past environment, some features omitted (due to generalisation) on a map could have been of great use. This is where aerial photography and satellite images come in handy. The up-to-date orthophotographic images used in this work were incorporated into the project via the Web Map Service (WMS) of Polish National Spatial Data Infrastructure portal (www.geoportal.gov.pl). The archive aerial photography used was selected on the basis of scale and date of the photograph. The 1:16 000 scale photographs of 1976 were the best solution, but it has to be mentioned that

the aerial photography of the People's Republic of Poland are not as easily available as maps. The collection is scattered among different institutions and covers selected, often small areas (especially towns and industrialized regions). The problem often encountered in the case of photography is the need for georectification using ground control points (GCPs) only (see below).

4.3. Terrestrial photography

The photographs of the research area were taken by the author during fieldwork and analysis in the summer months of 2012.

4.4. Rectification and geotransformation of raster data

The reference topographic maps and aerial photos were available in the '1992'coordinate system, the one currently used in Poland. Hence, all the data in the project should be in this system, including vectorised information, research results and other (older) raster data. This meant that these rasters had to be georeferenced and transformed into the'1992'system first.

1:10 000 maps in the '1965'system were obtained with geo referencing. They were loaded onto ArcGIS and, after checking the quality of the meeting points between contact zones, exported as a single '1992' GeoTIFF file. Flat-scanned sheets of 1:25 000 maps in the '1965' system were rectified using the maps' topographic grid. After successful quality checks with 1:10 000 sheets, it was also exported to the GeoTIFF format. The 1:10 000 reference sheets of the '1992' system have been registered based on its topographic grid.

The remaining materials (archive aerial photography) came with no information about their geometric quality and spatial reference. There was a need to transform and georeference these materials.

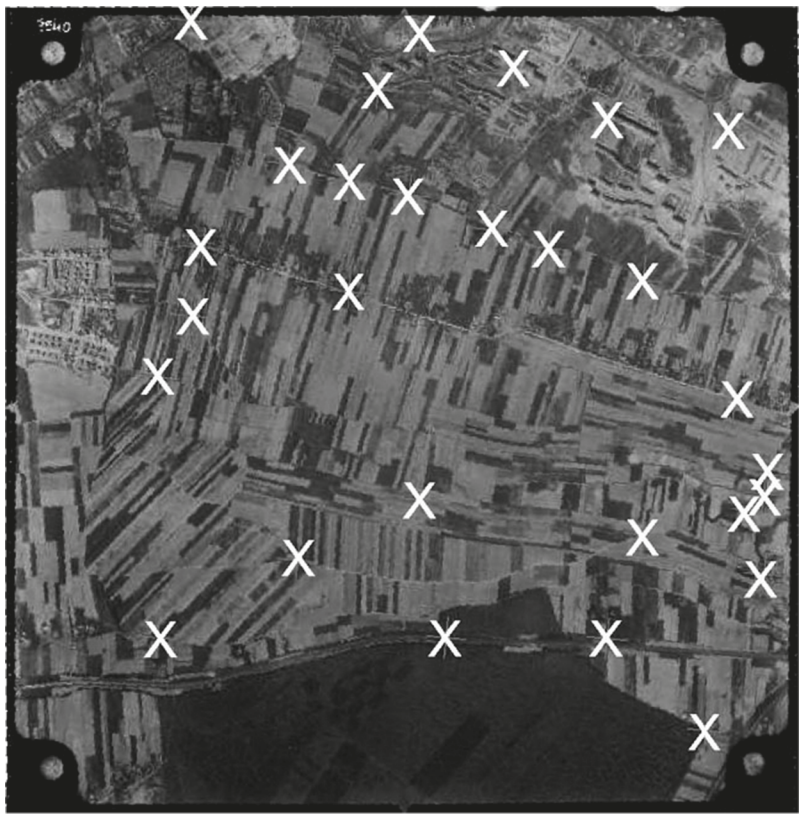

Fig. 3. Distribution of GCPs for an aerial photo

Source: author's work using archive aerial photography

The orthophotography used was of good quality and had quite a reliable geometry with the circular scale change towards the edges typical of aerial photography. It lacked any graticule, which meant that it had to be georeferenced using topographic features. Ground control points used for geo referencing should be distributed regularly and refer to an object of maximum reliability. This was not always possible, as for aerial photo GCPs it was easier to define them in the northern part, showing the built-up areas of the village and the LSM cooperative residential district with many characteristic features. The southern part, with large open areas of arable fields only, had fewer points. The distribution of 28 GCPs for aerial photo is shown on Fig. 3.

The transformation used to correct and geo reference materials with no coordinate system was the spline method which secures a precise real location of selected points. The accuracy achieved is local (unlike minimising global accuracy error and receiving an imprecise location of a GCP in polynomial transformations. This was tested and showed few unsatisfactory results even for aerial photography) and it is ideal for geo referencing materials of unknown geometric qualities.

5. Landscape analyses

A two-dimensional visual landscape comparison is the most basic. It can be done on a very simple level just by setting two maps from different periods side by side and pointing the differences out. GIS software lets us go further however, working on layers and superimposing one map on another. That idea is nothing new, but IT tools speed up the process significantly, especially in the case of maps of different geometric qualities and reference systems when complex image transformations are needed. This enriches the visual comparisons and gives an extra quality – all kinds of elements (geometries) can be vectorised and compared this way in GIS, using linear (multiline), areal (polygons) and point vector classes along with raster data (maps and aerial photos).

The gathered raster data were georectified and transformed into one reference system ('1992'). Before vectorising and analysing the data, the rasters were organised, together with other feature data in one storage container, a geodatabase file.

5.1. The visual comparison – defining exact topics of investigations

Having gathered all the data, it was possible to compare elements of past and modern environments and to find potential areas and subjects of interest. These are listed below.

1. The main village road now partly serves as a district street (Jutrzenki St in Ruta and partly as Tatarakowa St in Łęgi). Exact correlation should be analysed more deeply.
2. Most of the fields and less important village roads seem to be defunct with a few exceptions.
3. The past road network should be compared in detail with the current one.
4. Most of the area in the past was occupied by fields. It is possible the boundaries still shape the area, but that would need analyses on a geodetic scale.
5. Orchards and buildings were aligned along the main village road. Some of them still exist. There are two houses still inhabited, with a completely changed environment around them. The orchard areas should be vectorised and compared with a modern map and field work results.
6. Some cultural elements are also preserved – the spatial organisation defined by a road network (mentioned previously) and (more materially) a crossroads shrine.

All of the above were examined in detail in the following parts.

5.2. Feature extraction (linear features – roads)

The analysis of the road network was based on a comparison of the past with the present by means of overlaying roads vectorised from the old material onto a modern map. The source material was the 1970s aerial photography. The reason for this was as follows:

— aerial photography is not generalised, which means (potentially) every road is visible on it; a map is, on the contrary, generalised and the

criteria do not ensure the roads needed for the analysis are included (roads were generalised to show the network of the time, with no correlation to then non-existing (obviously) modern network);
— the earlier map of the same scale shows the 1980s situation with blocks of flats already built instead of the village older maps are at a scale of 1:25 000, so roads are not only generalised according to a different road system, but also to a smaller scale.

The roads were digitised as a linear feature. In the next step, they were displayed on the modern map and, according to topographic map and field work results, split into smaller segments. 65 were identified and each was assigned a numeric value in its attribute table. The attribute described the present state of the selected segment: '0' was assigned to those segments which are defunct in the current road network, '1' to those which are now asphalt streets (of differing importance), '2' to those which function as paved paths and '3' to those now unpaved paths.

5.3. Feature extraction (areal features – fields and orchards)

The introductory analysis showed that most of the study area was occupied by arable fields in the past. The village was spread along the main road(s) and so other than cereal crops most agricultural activities were in the form of domestic gardens, orchards etc.

Arable fields were turned into residential estates and there is no longer any clear evidence mainly because they were seasonal unlike an orchard where fruit trees are long-lived and much easier to analyse. Hence, orchards, as previously mentioned, were aligned along the main road and were easy to correlate with the modern environment. Besides these, cultivated fruit trees and garden plants are often remnants of the past that can be easily traced (Vujaković, 2012).

The first step was a vectorisation of the past state. This time, unlike the road analysis, two sources were used: aerial photography and a 1:25 000 map in the '1965' coordinate system. The reason for using photographs was as before: they are a quantitatively non-generalised source and allow different types of domestic gardening (without qualitative generalisation) to be distinguished. The map is generalised in both ways, which can also be an advantage because not all areas can be easily detected as orchards on the aerial photo, as this requires both knowledge and remote sensing skills. Orchards were digitised as polygon features, one for the aerial photo data and one for the topographic map.

5.4. Feature extraction (point features)

Beside linear and areal features, point features can be analysed as well. As far as natural elements are concerned, there are fair-sized trees which were left untouched and are still growing along the former main road. The only way to discover such remains is to use GPS-assisted field work together with photographic documentation. Topographic maps are of no use here, as they do not record single trees, aerial photography, however, can be of some help.

5.5. Application and results (road network analysis)

Roads a linear feature class were displayed on the modern map with qualitative colour distinction according to attribute values described in the methodology (feature extraction) section. The result is shown on Fig. 4.

It can be clearly seen that the main village road (central WNW – ESE line, with long black-coloured segments) partly serves as an internal estate road now. It forms a part of Wiklinowa St (most western) and then a long section of Tatarakowa St, crossing the main dual carriageway (Armii Krajowej) and continues as Jutrzenki St (Fig. 5) east toward a former crossroads where there is an interesting deviation. It turns NE, not copying the former road exactly, but in general some 280 metres to the east. This change could have been caused by several factors. Land ownership is less probable (during the People's Republic of Poland private land was, when needed, easily taken over by local government), topography is more likely, as the village road ran along an edge of a dry valley. It could have ended up collapsing due to landslides, so its position

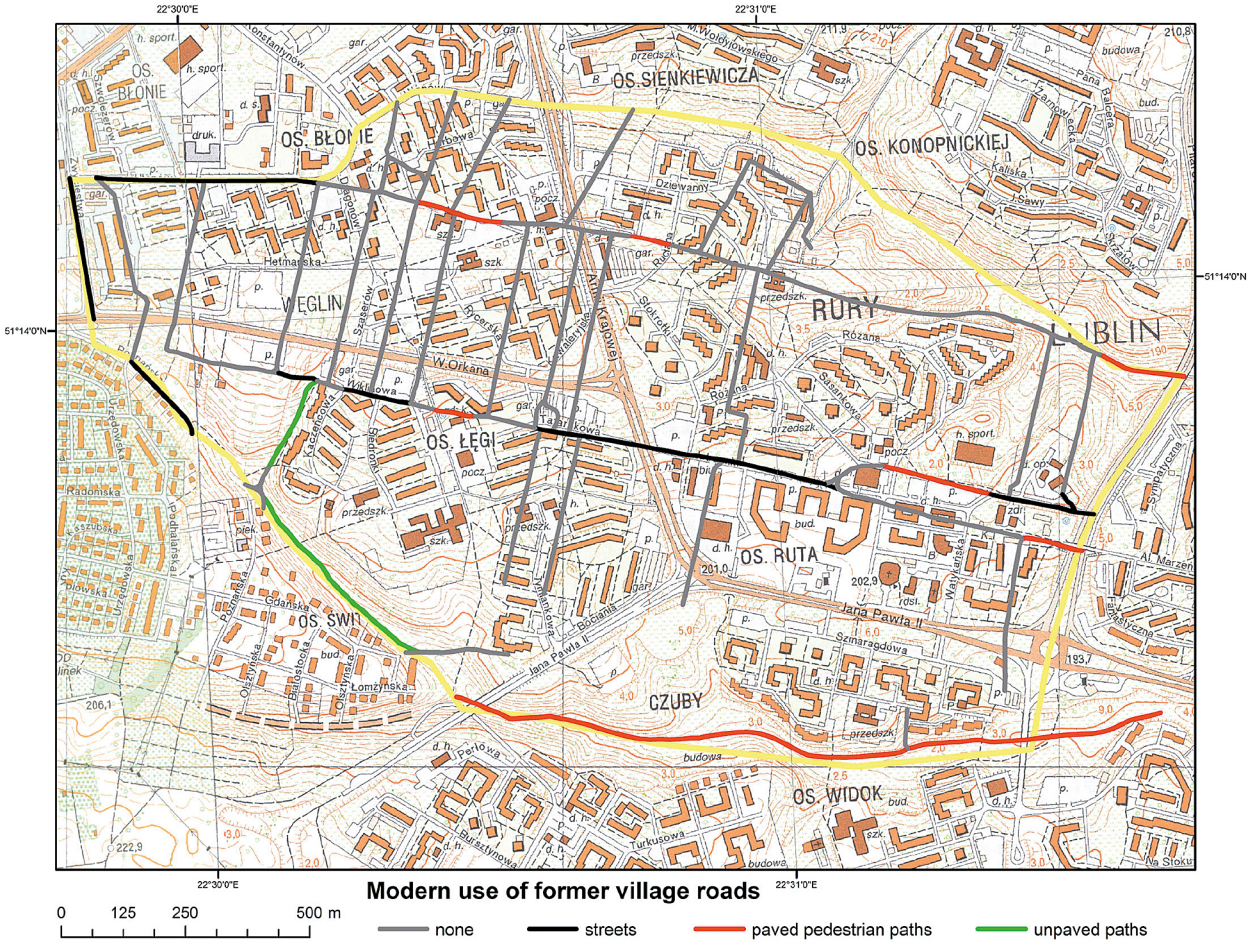

Fig. 4. The result of road network analysis

Source: Author's work using a topographic map ('Układ 1992', M-34-34-A-c-1)

was moved slightly. Other factors in such a situation could be the Skarpa estate paved path (a few years older) running along a smaller village road (entering the analysed area from the east and continuing for over 100 metres) or plans to build a sports hall with its infrastructure (it was started, but never finished).

Other segments of roads, now streets, are on the edge of the research area. These are a section of the small Poznańska St and a part of Ułanów and Zwycięska Sts, important on the estate and separating it from a commercial area. The latter two used to be village roads of higher rank, but not as high as the main Rury Wizytkowskie road described above.

Smaller sections of the main road are now paved and pedestrianised as is a part of the deviation of Jutrzenki St. It is the same to the north, where the other parallel road, is partly used as a paved path

Fig. 5. Jutrzenki St as seen from the eastern end of Tatarakowa St (both are parts of the former village road)

Source: Author's work

Fig. 6. The bottom of the dry valley, functioning as a park; a cycle track follows (on this section) an old village road, a footpath is above

Source: Author's work

Fig. 7. An old orchard separated from a block of flats by a grassed over former village road

Source: Author's work

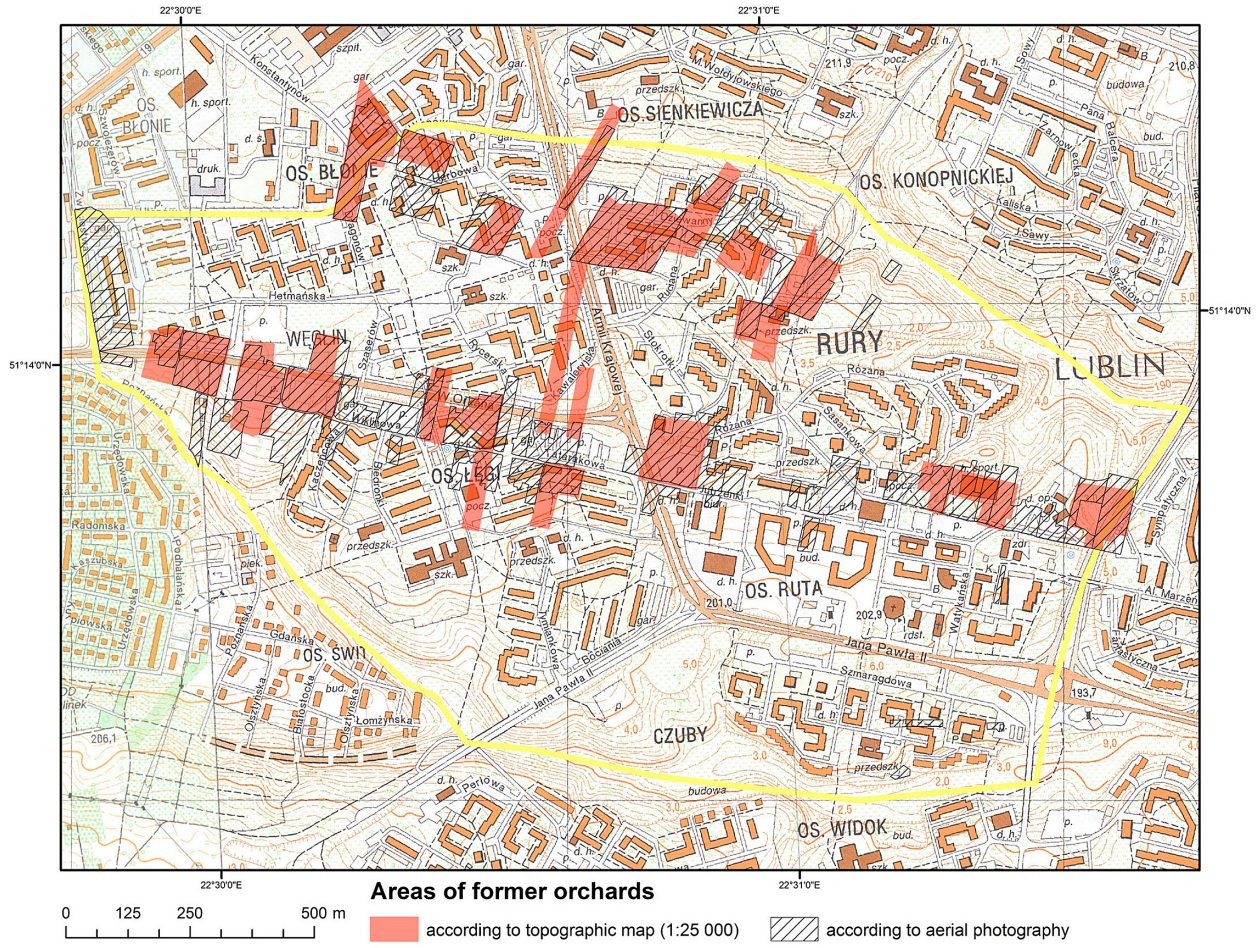

Fig. 8. Former orchards, domestic gardens and property boundaries in the present day context

Source: Author's work using a topographic map ('Układ 1992', M-34-34-A-c-1)

Fig. 9. Individual fruit-trees on a residential estate (left: a mirabelle plum typical of private rural kitchen gardens, right: group of trees with pears)

Source: Author's work

Fig. 10. A modern view of two old trees together with their 1976 aerial image

Source: Author's work

now. The longest paved section of the former village road is on the southern edge of the research area. For many years it was a path in the wasteland of the dry valley, but was turned into a park in 2009 with cycle and paved footpaths side by side on the line of the former path (Fig. 6). Going east, the paved path turns north and leaves the old village road which then becomes an almost unused path.

The other significant grassed over path (former road of quite high importance) can be seen on the eastern edge of the Łęgi estate, going south alongside an old orchard (Fig. 7) and joining a path in the main dry valley.

It is interesting that none of the north-south (in general) routes joining the two long parallel village roads are used nowadays. The only N-S road

is Zwycięska St linking to a main street at the end of the main village road.

To sum this analysis up, the modern system is based solely on the former west-east roads, which are highly topography-dependant: Jutrzenki St goes along the former main village road on the higher land between the two dry valleys, the park path is in one of those valleys and none of the roads cross this higher land.

5.6. Application and results (land use analysis)

Both polygon feature classes of the land use feature dataset were displayed on the modern map, as seen on the Fig. 8. It became a base for the fieldwork – vectorised areas were investigated and some interesting cases are described below.

Most of the remains are single fruit trees near unbuilt-up parts of the estate, as those shown on the left image of Fig. 9. They were left untouched and their form suggests they have gone wild now. There are some reasons to treat them as remnants of past domestic gardens. One is that they fit into areas selected during analysis and shown on Fig. 8, the other is that they are cultivars of plums and pears. Such trees (in a group) can also be seen on the right-hand image. The group remained untouched because this was planned as a small green, grassy area with pedestrian paths only.

The edges of the estates are mainly unchanged which has allowed larger orchard areas to be left untouched. One example was mentioned previously (see Fig. 7); the other is found on an 'empty' area west of Szaserów St on the Błonie estate. Land-ownership problems resulted in this space being unbuilt for many years. Now the situation has changed a little and a commercial building has been constructed, but the large group of fruit-trees that have gone wild, self-sown trees and shrubs still exist, forming a chaotic 'jungle' surrounded by the city.

5.7. Application and results (point feature analysis)

Field reconnaissance results and GPS locations were compared with the aerial photo and Fig. 10 shows two examples of old trees in the modern estate environment.

Special cases of a point feature that survived the total environment reshaping are shrines. They, as characteristic features, are present on topographic maps, so it was possible to locate them on the maps used in this analysis. There are two Rury Wizytkowskie crossroad shrines still existing, but only one is located in the research area. It used to be a shrine on a crossroads and is on a small hillock now between the main road and a large parking place surrounded by trees (Fig. 11). Most of its functions are now gone, but it is still taken care of by former village inhabitants, as a few such families now live in nearby blocks of flats.

Fig. 11. Modern view of the crossroads shrine in a group of trees

Source: Author's work

Another interesting point feature is a well. Rury Wizytkowskie spread west from the Bystrzyca river valley and the research area is from 1 to 3 km away from the river. Topographic maps show one important well in the analysed area which can be seen on both 1:10 000 and 1:25 000 '1965' system maps and

on the modern '1992' system map. Closer investigation showed this is not a village well with a concrete ring but is over 80 metres deep. It was drilled in 1973, with Czuby district construction work needs in mind. The well is defunct and its current state is shown on Fig. 12.

Fig. 12. Deep well – modern view and 1:25 000 system '1965' map (round blue symbol)

Source: Author's work

6. Discussion of results and conclusions: visual comparison summary

The results are more than satisfactory, especially with features easily distinguishable in the field. Vectorising an old road network and overlaying it onto a modern one is a step towards finding which segments still serve as a means of communication. The analysis conducted showed the main village road is still in many parts used. A few other segments changed their mode of use and importance, becoming paved or recreational paths in the park. It is topographically interesting that no single short perpendicular segment exists nowadays.

Areal features are less visible. Due to serious environmental changes during the estate construction process, areas (orchards) were far less likely to stay untouched compared to the linear element of roads. Hence the only orchard still existing is located at the west end of Łęgi, at the edge of the built-up area. The rest are just patchy leftovers of past human activities. A few interesting cases of human point-features were also analysed.

The goal of the article is to analyse the rural landscape and evaluate if and what early source materials can be used. Maps are of great value, but in some aspects aerial photography is better. There are two main advantages to such images. They are not quantitatively generalised, so there is no risk of omitting an element that could serve as important evidence when compared with the present day, for example a less important segment of the road which is now used as a paved path. Besides this, they show the whole (lack of qualitative generalisation) and let common single elements, like bigger trees, be compared which are not available on maps,. On the other hand, maps show special single point elements that are hard or impossible to distinguish on a photograph. Interesting topographic features can be mentioned here, like wells or special-use buildings not always clearly seen on aerial photos and small orientation point features, like crossroad shrines. Both maps and aerial photos can be used in research, especially when it is possible to look at them alongside one another. The analysis of orchards showed some differences between the two sets of early materials (map and aerial photo), but the general image was correct (similar). It should be kept in mind that the differences were also a result of the slightly different ages of those materials.

The above conclusion regarding maps and photos may seem obvious but it has to be stressed that it stands as an answer to the question about source material content however. Both aerial photography and '1965' system maps can be used in environmental research on condition they are properly georectified. This process often needs a precise identification of reference points, especially when no coordinates are given (as in the case of aerial photography). The problem of verification of geometric quality in relation to the content of maps (including those used here) is presented in another paper (Nieścioruk, 2014).

7. Conclusions and further steps

The work showed that archive post-war maps can be treated as early maps they have their own value and can be useful from various aspects. The quality of these materials differs. Examining and analysing them with an appropriate attitude, knowledge and preparation,

can lead to valuable results. The case study proved that post-war cartographic materials store a lot of information and, properly combined with fieldwork and analytical tools, can reveal past spatial relationswhich are very hard to discover using other materials or only field reconnaissance. The set of maps defines the scope of research from landscape analyses (possible with just topographic maps) to a virtual representation of a past environment which needs a lot more cartographic information (geodetic and topographic maps combined with aerial photography).

This paper describes multi-feature analyses of a past environment which has been limited to two-dimensional relations. Georectified maps, aerial photography and land use information together with a 2.5-dimensional model in the form of DEM and vectorised contour lines are a further step towards creating a virtual landscape. This task is beyond the scope of this paper, but it could be done as a further stage. Aerial photography brings information about land use; in addition, it can be used as texture to wrap onto shaded relief on a base of DEM. Ground-level photos of a past landscape (trees, shrines) can also be used as graphic representations of single features. Other elements can be obtained from maps. 1:25 000 or even 1:10 000 maps are not enough to construct a detailed image of buildings in a 3D environment. Such a task requires a geodetic level. Archive 1:1000 maps would be suitable, giving exact information about single buildings and their use, together with infrastructure (utility poles, wells etc.). All this should be sufficient to create a virtual representation of a past landscape.

Acknowledgements

This article is partly based on the author's thesis in GIS, prepared under the supervision of Prof. Jacek Kozak of Jagiellonian University in Kraków, Poland.

References

Grygorenko, W., 1991: Kartografia Polska w latach 1945--1990 w potrzasku reorganizacji i cenzury (Polish cartography during the period of 1945-1990 caught in a trap of reorganisation and censorship – in Polish). In: *Polski Przegląd Kartograficzny*, T. 23, Nr 1-2, pp. 1-7.

Kardaś A., Chmielewski J.M. and Turek A., 2014: Tendencje rozwoju pasma północnego obszaru metropolitalnego Warszawy (Development trends of the northern part of Warsaw metropolitan area – in Polish). In: *Studia Regionalne i Lokalne* 2(56), pp. 68-94.

Konopska, B., 2011: Geometryczne deformacje treści polskich planów miast do użytku ogólnego w latach 1955-1981 (Geometrical distortions in Polish general use map content in the years 1955-1981 – in Polish). In: *Polski Przegląd Kartograficzny*, T. 43, Nr 4, pp. 354-368.

Nieścioruk, K., 2013: Cartographic source materials and cartographic method of research in the past environment analyses. In: Szymańska, D. and Biegańska, J. editors, *Bulletin of Geography. Socio-economic Series*, No. 22, Toruń: Nicolaus Copernicus University Press, pp. 81-95, DOI: http://dx.doi.org/10.2478/bog-2013-0033

Nieścioruk, K., 2014: Weryfikacja wiarygodności treści map dawnych z wykorzystaniem cyfrowego modelu terenu i podstawowych atrybutów topograficznych (Verification of content credibility of early maps with application of digital elevation model and primary topographic attributes – in Polish). In: Konopska, B. and Ostrowski, J. editors, *Dawne mapy jako źródła w badaniach geograficznych i historycznych. Z dziejów kartografii*, Tom XVIII, Warszawa: Instytut Historii Nauki PAN. Zespół Historii Kartografii, Uniwersytet Marii Curie-Skłodowskiej w Lublinie. Katedra Geomatyki i Kartografii, Katolicki Uniwersytet Lubelski. Ośrodek Badań nad Geografią Historyczną Kościoła w Polsce, Instytut Geodezji i Kartografii, pp. 53-64.

Nowicki, J., 1991: Koncepcje i metody działania w procesach realizacyjnych (Conceptions and methods in processes of implementation – in Polish). In: Malisz, B. editor, Przemiany i rozwój planowania miast i urbanistyki, *Biuletyn – Polska Akademia Nauk. Komitet Przestrzennego Zagospodarowania Kraju*, Z. 152, pp. 189-203.

Saliszczew, K.A., 1998: Kartografia Ogólna (General cartography – in Polish), Warszawa: Wydawnictwo Naukowe PWN.

Vujaković, P., 2012: Spider's moving Castle: re-inscribing a 'sense of place'. In: *Maplines*, Vol. 18, Issue 1, pp. 10-11.