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## THE USE OF LIDAR DATA TO ASSESS ELEMENTS OF RURAL LANDSCAPE ARCHITECTURE

### WYKORZYSTANIE DANYCH LIDAROWYCH DO OCENY OBIEKTÓW ARCHITEKTURY KRAJOBRAZU OBSZARÓW WIEJSKICH

#### Abstract

**Background.** The aim of the study was to assess the possibility to apply airborne laser scanning data (LIDAR) for assessment of elements of rural landscape architecture and to indicate different methods of space visualisation. The research was conducted in the village of Siemczyno, commune of Czajlinek, West Pomeranian Voivodeship.

**Material and methods.** The analysis was based on airborne laser scanning data (LIDAR) in the form of a point cloud (.las file format). The data were used for inventory of medium and high vegetation as well as for their evaluation and visualisation, using the ENVI and ArcMap 10.2 programs.

**Results.** The first stage of the research involved an inventory and assessment of elements of landscape architecture, which significantly affect the form and perception of rural space. The manor and grange complex with a baroque garden in Siemczyno was chosen on this basis. The complex has natural, cultural and tourist values. LIDAR data were used to make visualisations and to assess the baroque garden complex.

**Conclusions.** The study showed that LIDAR data can be used as input material for landscape analyses and space visualisations. The data can also be used for the inventory of elements of culture (buildings, roads) and nature (parks, forests, buffer strips, lakes).

**Keywords:** GIS, LIDAR, rural landscape, Siemczyno

#### Introduction

Landscape is a very complex concept, related with the activity of natural and anthropogenic elements. According to Żarska (2001), it synthesises the natural, cultural

and visual environment. Landscape has been developing in different ways in different regions of Poland. The quality of ecological structure of landscape, which should be perceived in the qualitative, quantitative and spatial aspects, is very important for the maintenance of natural values and ecological balance.

Areas of high natural and cultural value are attractive for tourism. According to the nature conservation act of 2004 (Ustawa..., 2004), protected landscape areas and scenic parks are the most suitable for tourism and leisure. The tourist function programme should not collide with protection of natural values.

Airborne laser scanning (Lidar) is a method of acquiring data for landscape assessment. For many years these data have been used in natural, technological and geographical sciences (Andersen, 2002; Kwoczyńska and Bryś, 2012; Pham et al., 2016; Rieg et al., 2014). They contain information about terrain and its cover: high, medium and low vegetation, water, buildings, etc.

LIDAR is a method which enables acquisition of more precise data than the information from aerial photos. Laser scanning is thought to be one of the most accurate measurement techniques. It gives a possibility to record enormous amounts of spatial data at a high rate and precision, 3D terrain modelling as well as visualisation of complex buildings and structures (Michałowska, ed., 2015). These data can be used for analysis of landscape architecture, such as inventory and evaluation.

The aim of the study was to assess the possibilities to apply LIDAR data for assessment of elements of rural landscape architecture and to indicate different space visualisation methods based on a point cloud as the input data.

## Area of study

The research was conducted in the village of Siemczyno, commune of Czaplinek, West Pomeranian Voivodeship, on the land of Drahim. The place is located on the border of Drawsko Scenic Park, whose landscape was formed by a glacier.

Siemczyno dates back to the 16<sup>th</sup> century. Originally the village was named Heinrichsdorf after Heinrich von Beeskow, the founder or the first headman of the village. Later the name was polonised to Henrykowo and finally it was renamed to Siemczyno.

In the 16<sup>th</sup> century Siemczyno belonged to the von Golcz family. In 1597 they received property rights to this land from King Sigismund III Vasa. Additionally, the estate encompassed the surrounding villages of Piaseczno, Warniłęg and Broczyno (Leszczelowski, 2013).

## Methods

The first stage of the research involved assessment of scenically valuable elements of rural space and inventory of medium and high vegetation in the village of Siemczyno. The analysis was based on airborne laser scanning data (LIDAR) in the form of a point cloud (.las file format).

An estate of high cultural and natural values was selected for further analysis. The next stage of the research involved making different visualisations of the manor and grange complex in Siemczyno, followed by detailed analysis. The visualisations were made with the ENVI program, using a digital elevation model (DEM) and a digital land cover model (DLCM). This is an input material enabling 3D analysis and visualisations of any objects with all details (Wężyk et al., 2015). Then the data were also used for inventory of medium and high vegetation as well as their evaluation, using the ENVI and ArcMap 10.2 programs.

## Results and discussion

The first stage of the research involved valorisation of the rural landscape in Siemczyno. As a result, the following nine elements of considerable natural, tourist and cultural values were identified: the baroque palace, buildings in the manor and grange complex, the scenic axis leading towards the palace, park, church, the characteristic rural enclosure arrangement with high vegetation, the Evangelical cemetery and Lake Drawsko (Dudzińska and Szpakowska, 2014).

The next stage of the research involved inventory of the buildings as well as medium and high vegetation in the village of Siemczyno. It was based on data in the .las file format. The results were processed with Envi Feature Extraction Module and ArcMap 10.2 programs. The research proved that high vegetation was regularly distributed around the entire settlement. The rural park is the predominant element. It is directly linked to the forest and thus it forms an interconnected system of rural green space. The park was also assessed as a place of high natural and cultural value. Therefore, it was subjected to detailed analyses. It was established in the 17<sup>th</sup> century, when Siemczyno belonged to the von Golcz family. The baroque manor and grange estate (Fig. 1) is one of few estates in north-western Poland, which have been preserved till now.



Fig. 1. A visualisation of the manor and grange estate in Siemczyno (by A. Dudzińska)

The garden surrounding the palace was established in the 18<sup>th</sup> century (Fig. 2). Its area was larger than 3 ha. To the south a small forest complex, which may have been part of the composition, was linked to the original garden. There may have been a small menagerie in that place.

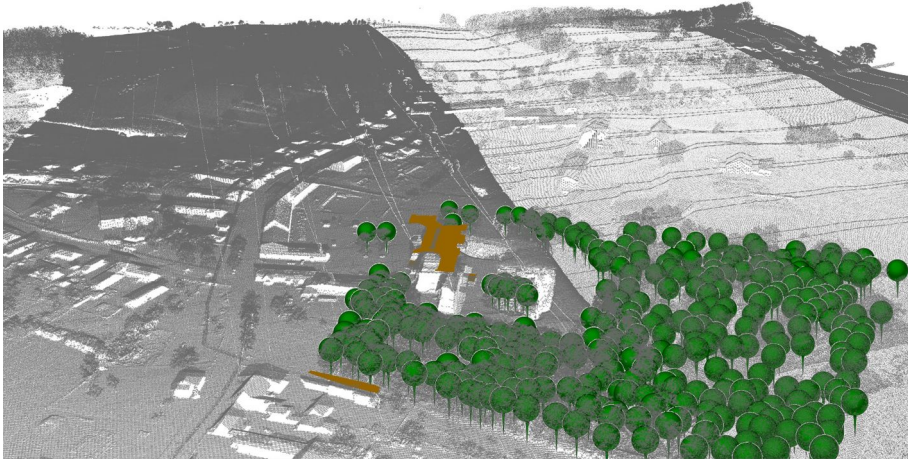


Fig. 2. A visualisation of the park in Siemczyno – the predominant element of the rural space (by A. Dudzińska)

Manor and park areas are often the only cluster of high vegetation. Therefore, further research involved an inventory of medium and high vegetation in the park (Fig. 3), assessment of the trees in the park and analysis of the spatial composition. The inventory was based on GIS analysis and field investigations.

15 tree species were inventoried in the park. Norway maple (*Acer platanoides* – 31%) and common hornbeam (*Carpinus betulus* – 30%) were the predominant species. Bykowska (2014) analysed the dendroflora of the historical park in Sobota (Greater Poland Voivodeship) and proved the presence of many native species. The presence of these species is strictly related to the character of the park. There is a hornbeam alley registered as a monument in the regular part of the estate. It is the predominant and very legible part of the park.

The research also included analysis of the height of the trees (Fig. 4). The trees in the regular part of the park were noticeably shorter (10–17 m tall) due to the predominance of the common hornbeam. There were taller trees in the naturalistic part of the park (lime, maple and conker trees). This part of the park is naturally linked to the forest landscape around Siemczyno. The analysis of the height of the trees in the park in Sobota revealed that the tallest ones (ash, lime and maple trees) reached the height of 20–25 m (Bykowska, 2014). The height of the trees in the irregular part of the park under study ranged from 17 to 37 m.

Numerous transformations of the regular garden into a naturalistic park involved considerable changes in the species structure and types of plant spatial arrangements. Therefore, at present it is very difficult to identify its original composition precisely.

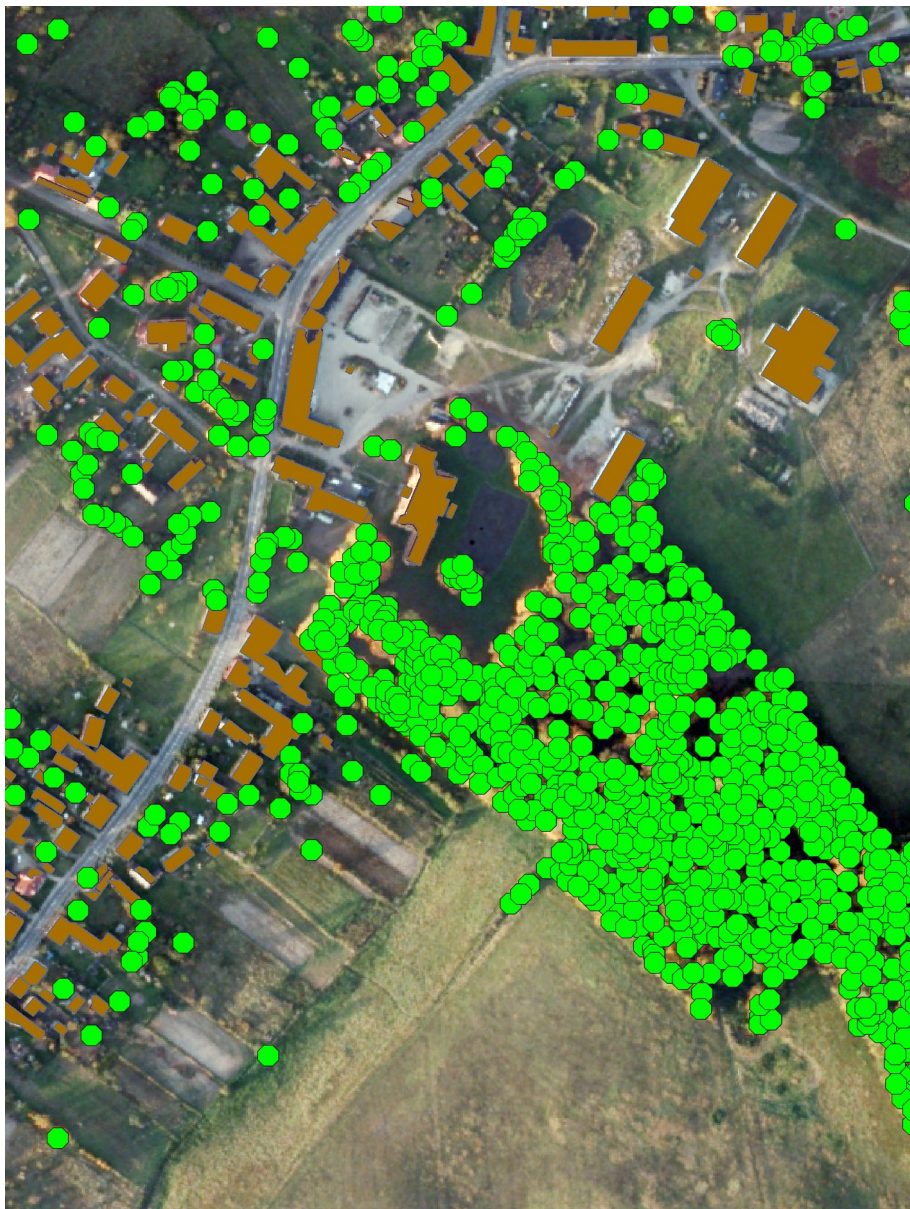


Fig. 3. An inventory of medium and high vegetation in the park of Siemczyno (by A. Dudzińska)

The simplified reconstruction ideogram shows the presumable baroque arrangement (Fig. 5). The composition scheme was based on archival cartographic, text and iconographic materials as well as field research. The compilation of the regular composition

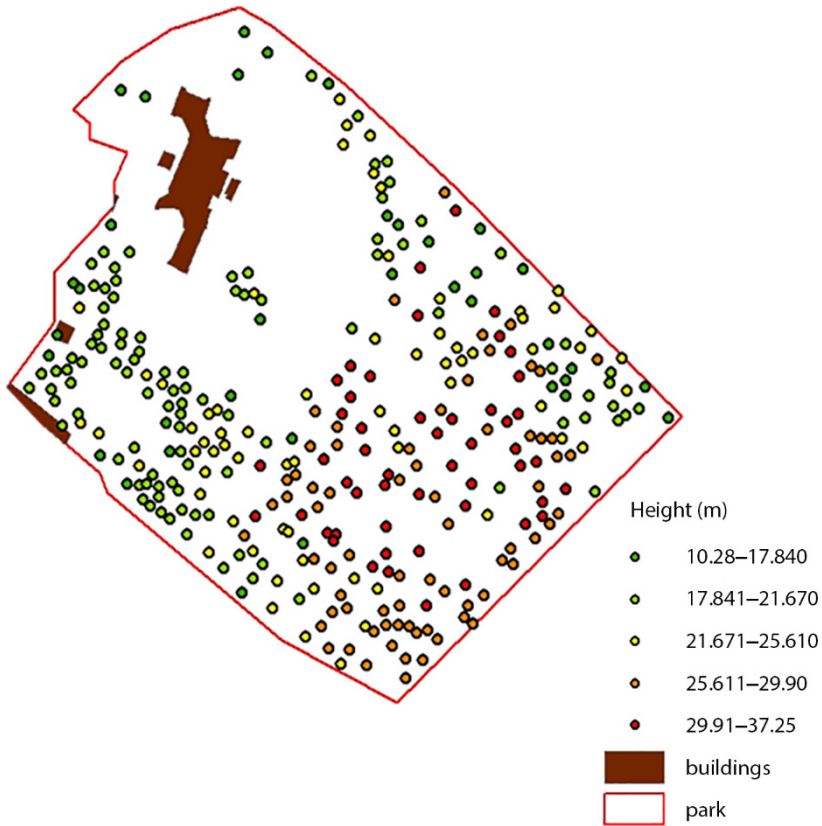


Fig. 4. The analysis of the height of high vegetation in the garden estate in Siemczyno (by A. Dudzińska)

ideogram with the results of the park inventory confirms the information about considerable transformations of elements of high vegetation in the 19<sup>th</sup> and 20<sup>th</sup> centuries. The baroque genesis of the park can only be proved by vestigial regular tree arrangements, especially in the southern part of the park.

## Recapitulation

Nature conservation and tourist development schemes should be based on the principles of ecodevelopment, which can be manifested by improved coexistence of these functions and mutual benefits. These recommendations also pertain to historical palace and park estates, which are inextricably linked with the Polish landscape. The park in Siemczyno is an interesting example showing how the estate was developed. It has both considerable natural and cultural values. The area can be developed so as to give it a high tourist value and simultaneously, to protect it. The park could promote the village



Fig. 5. A scheme of the composition of the park in Siemczyno: a – a scheme of the regular road system, b – a simplified projection of major elements, c – an ideogram of the axis arrangement and nodes of the composition (by M. Walerzak)

and the land of Drahim. Its history is very interesting because for a long time it was a borderland area and the division line between two religions: Catholicism and Protestantism.

The palace and garden complex in Siemczyno is a facility of high cultural, historical and scenic significance. The large green space complex, which is predominant in the panorama of the village and its surroundings, has unquestionable scenic values. Apart from that, its significant value for the cultural heritage of Poland is a big asset and important attraction of the region. At present the complex, especially the park, is not in good condition. However, it has enormous potential and all possible indications for revalorisation and restoration of old historical values.

The study was based on LIDAR data, which can be used as input material for landscape analyses and space visualisations. The data can also be used for the inventory of elements of culture (buildings, roads) and nature (parks, forests, buffer strips, lakes).

Airborne laser scanning uses a laser impulse to determine distances between objects on the earth surface. LIDAR data are characterised by high spatial accuracy. Therefore, as Rieg et al. (2014) indicate, in recent years they have become a standard element helping to draw maps and to monitor changes in the natural and cultural environment. The study also shows how the data can be processed into space visualisations, which are an essential tool used by landscape architects. Michałowska (ed., 2015) shows that 3D visualisations and data can be important elements helping clerks to make important spatial decisions, such as issuing administrative decisions (shading, the height of buildings and the angle at which the roof slope is inclined).

## References

- Andersen, H. E. (2002). The use of airborne laser scanner data (LIDAR) for forest measurement applications. Washington: WFCFA.
- Bykowska, J. (2014). Zmiany w strukturze dendroflory i kompozycji zabytkowego parku w Sobocie (województwo wielkopolskie). *Nauka Przyr. Technol.*, 8, 1, #11.
- Dudzińska, A., Szpakowska, B. (2014). Method of landscape evaluation and elaboration of protection for individual elements of the rural space of the Drawski Landscape Park. *Nauka Przyr. Technol.*, 8, 2, #17.
- Kwoczyńska, B., Bryś, M. (2012). Ocena zastosowania integracji danych lidarowych i fotogrametrycznych do generowania NMT dla okolic zbiornika wodnego Chańcza. *Infrastrukt. Ekol. Teren. Wiej.*, 2, 2, 171–186.
- Leszczelowski, J. (2013). Rozważania o początkach wsi Heinrichsdorf. *Zesz. Siemcz.-Henryk.*, 2, 41–52.
- Michałowska, K. (ed.). (2015). Modelowanie i wizualizacja danych 3D na podstawie pomiarów fotogrametrycznych i skaningu laserowego. Rzeszów: Wyższa Szkoła Inżynierjno-Ekonomiczna z siedzibą w Rzeszowie.
- Pham, L. T. H., Brabyn, L., Ashraf, S. (2016). Combining QuickBird, LiDAR, and GIS topography indices to identify a single native tree species in a complex landscape using an object-based classification approach. *Int. J. Appl. Earth Obs. Geoinf.*, 50, 187–197. <https://dx.doi.org/10.1016/j.jag.2016.03.015>
- Rieg, L., Wichmann, V., Rutzinger, M., Sailer, R., Geist, Th., Stötter, J. (2014). Data infrastructure for multitemporal airborne LiDAR point cloud analysis – examples from physical geography in high mountain environments. *Comput. Environ. Urban Syst.*, 45, 137–146. <http://dx.doi.org/10.1016/j.compenurbysys.2013.11.004>



- Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody. (2004). *Dz. U.*, 92, poz. 880, 6056–6099.
- Walkiewicz, R. (2013). Szlacheckie dwory i pałace na Pomorzu Zachodnim w okresie renesansu i baroku. *Zesz. Siemcz.-Henryk.*, 3, 108–122.
- Wężyk, P., Szostak, M., Zięba, K., Rysiak, P., Hawryło, P., Ratajczak, M. (2015). Preliminary results of the monumental tree monitoring based on terrestrial laser scanning – a case study of the Oak Bartek in Zagnańsk (Poland). *Arch. Fotogram. Kartogr. Teledetekc.*, 27, 185–200.
- Żarska, B. (2001). Study of landscape protection – methodics of working out for various areas. *Ann. Warsaw Agric. Univ. – SGGW-AR Hortic. (Landsc. Archit.)*, 22, 111–122.

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### Abstrakt

**Wstęp.** Celem badań była ocena możliwości zastosowania danych pochodzących z lotniczego skaningu laserowego (LIDAR) do oceny obiektów architektury krajobrazu obszarów wiejskich oraz wskazanie różnych możliwych sposobów wizualizacji przestrzeni. Badania zostały wykonane w województwie zachodniopomorskim, w gminie Czaplinek, na obszarze wsi Siemczyno.

**Materiał i metody.** Do analizy wykorzystano dane z lotniczego skaningu laserowego (LIDAR) w postaci chmury punktów (plik z rozszerzeniem: .las). Wykorzystano je do inwentaryzacji roślinności średniej i wysokiej oraz do jej oceny i wizualizacji z zastosowaniem programów ENVI i ArcMap 10.2.

**Wyniki.** Pierwszym etapem badań była inwentaryzacja i ocena obiektów architektury krajobrazu, które w istotny sposób wpływają na kształt i odbiór przestrzeni wiejskiej. Na tej podstawie wybrano zespół dworsko-folwarczny z barokowym ogrodem w Siemczynie. Obiekt ten ma walory przyrodnicze, kulturowe i turystyczne. Wykorzystując dane lidarowe, opracowano wizualizacje oraz dokonano oceny barokowego założenia ogrodowego.

**Wnioski.** W pracy wykazano, iż dane lidarowe można wykorzystać jako materiał wyjściowy do analiz krajobrazu oraz tworzenia wizualizacji przestrzennych, a także do dokonywania inwentaryzacji zarówno obiektów kulturowych (zabudowa, drogi), jak i przyrodniczych (parki, lasy, zadrzewienia śródpolne, jeziora).

**Słowa kluczowe:** GIS, LIDAR, krajobraz wiejski, Siemczyno

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*Accepted for publication – Zaakceptowano do opublikowania:*

*26.10.2017*

*For citation – Do cytowania:*

*Dudzińska, A., Szpakowska, B., Walerzak, M. (2017). The use of LIDAR data to assess elements of rural landscape architecture. *Nauka Przyr. Technol.*, 11, 4, 397–405. <http://dx.doi.org/10.17306/J.NPT.00209>*