THE GENERATION OF A SWIMMING POOL CADASTRE FOR GRAZ (1945 – 2015)

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Abstract
The generation of a swimming pool cadastre for Graz (1945 – 2015)
This paper deals with the generation of a swimming pool cadastre for Graz by means of multitemporal analyses of aerial photographs. Twelve temporal steps between 1944/45 and 2015 are analysed partly by digital image processing and visual mapping. The result shows an enormous increase of private swimming pool between the 1990 (600) and 2015 (5600). The distribution of swimming pools and their different types shows specific patterns, which can be geographically interpreted by social settlement structures.
Key words
Aerial photography, cadastre, social structure, Graz

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1. Introduction

The problematic of water shortages on the first day of spring as a result of the simultaneous filling of private swimming pools by the inhabitants has been stated in several newspapers and -groups in Austria (for example http://ooe.orf.at/news/stories/2770977/). To get an overview about the quantities of private swimming pools in the city of Graz this survey was conducted actual and historical aerial images. A swimming pool cadastre from 1944/45 to 2015 for Graz was created, to be able to approximately quantify the used water amount.

Especially in the dry touristic Mediterranean regions like Spain several studies to get hold of the water volume and thus evaporation of private swimming pools have been conducted (Hof , Schmitt 2011; Hof, Wolf 2014).

During their history swimming pools had a change in their meaning as social status. To have an own swimming pool on your terrace or in your garden was a symbol of prestige and an aspect to improve the quality of life (Niemitz 2004, Silberschneider 2015). Today swimming pools are not symbols and statuses for prestige any more but they still implement a certain lifestyle. It is not something that only wealthy people can afford but it has reached, thanks to the technical development and the new materials and shapes, also the population with limited financial income. This leads to the fact that nowadays many households own a private swimming pool in their gardens, backyards, patios and terraces (Silberschneider 2015). The main reasons for buying a swimming pools stated by the interviewed people by Silberschneider (2015) were: The dream of owning one as a kid, to avoid extra costs and time for going to a public swimming place (especially when having a family with kids) and the quietness and privacy you can enjoy while swimming in your pool. Today's lifestyle of stress and precipitance makes people search for calm areas which are often found in owning a private swimming pool where you can relax. However not only the need for tranquillity leads people to buy swimming pools but also the growing trend to stay fit and healthy and the development of new materials a new sort of leisure time arose. These are all reasons to denounce the swimming pool as a status symbol for society but to state swimming pools as an ordinary consumer good of the 21st century and part of our lifestyle (Silberschneider 2015).

2. Methodology

Data basis for this study were orthorectified images of Graz (see table 1) from 1944/45 to 2015. An important aspect and a problematic in this study was the time the images where shot. Some swimming pools are, due to the seasons in one year, temporal (Silberschneider 2015), and thus if the images were not taken at approximately the same time of the year the acquired data is not perfect for a time series analysis (Salentinig 2012). This can be seen in the results of this study as the images were not always taken on the same month (Tab. 1). Another aspect is, as a result of the tremendous improvement of remote sensing data, the changing spectral and spatial resolution (Salentinig 2012). Until 2004 the used images had a low spectral and spatial resolution and therefore where harder to interpret than the images taken in the 21st century.

Tab. 1: Data basis for the survey.

Year	Month	Scale/ spatial resolution	Source
1944/45	April	appr. 1m	Amt für Stadtvermessung
1953	September	1:14.000 – 1:23.000	Bundesamt für Eich- und Vermessungswesen
1956/59	April/ October	1:2.500	Amt für Stadtvermessung
1968	June/ October	1:11.000 – 1:18.000	Bundesamt für Eich- und Vermessungswesen
1975	May / June	1:23.000 - 1:31.000	Bundesamt für Eich- und Vermessungswesen
1984	October	1:27.000 - 1:34.000	Bundesamt für Eich- und Vermessungswesen
1990	October	1:27.000 – 1:35.000	Bundesamt für Eich- und Vermessungswesen
1997	April	Resolution: 100cm	Bundesamt für Eich- und Vermessungswesen
2004	September	Resolution: 50cm	Amt für Stadtvermessung
2007	September	Resolution: 50cm	Amt für Stadtvermessung
2011	June	Resolution: 50cm	Amt für Stadtvermessung
2015	April	Resolution: 50cm	Amt für Stadtvermessung

Due to the usage of heterogeneous data, from panchromatic orthorectified images to multispectral images taken with UltraCam, the mapping of the swimming pools was done visually. For the multispectral images that had an infrared channel water indices where calculated to better differentiate the swimming pools from trampolines which could have a similar form and were thus not easy to differentiate.

Owing to the big study area a systematic screening of the images was needed. The first image analysed was from 2011. Every district of the city of Graz was reviewed one by one by vertical strips which were overlapping with approximately 100 meters. After the mapping of the year 2011 the other years where mapped backwards until 1944. Every pool which was mapped in 2011 was selected and looked at in the other years. If there was no swimming pool before it was deleted from the list or if there was a change the change got mapped. After checking one pool a zoom out to a scale of 1:15.000 was conducted to make sure that no swimming pool could have been overlooked. For the year 2015, which got mapped after the year 2011, another systematic observation of the districts had to be carried out because new pools could have been built or set up.

Thanks to the manifold possibilities, by cause of the improving technologies concerning materials, many shapes and functions of private swimming pools can be found. There are two principal differentiations to be made: On the one hand there are above ground basins, which are set up and can be removed easily, and on the other hand there are inground swimming pools which are built into the floor and in consequence are constant (Silberschneider 2015). In this study the mapped swimming pools where differentiated on the basis of their shape and function as can be seen in Tab. 2 and Fig. 1. The numbers from Tab. 2 where added to the attribute table of the shapefile. Owing to the low spectral and spatial resolutions of the images taken in the 20th century a differentiation between the functions was not possible anymore and thus left out.

Tab. 2: Attributes given to the swimming pools.

Form		Function	
0	Pond	0	Pond
1	Round	1	Outdoor
2	Angled	2	Indoor
3	Hybrid	3	Not clear

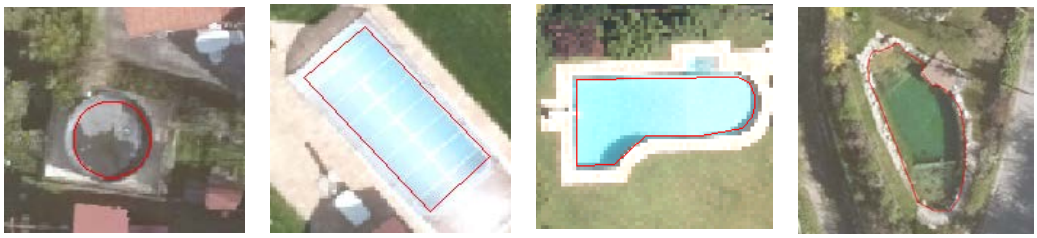


Fig. 1: Different shapes of swimming pools (round, angled, hybrid and pond).

The infrared wavelengths are absorbed by water features (Pope, Fry 1997) which makes them appear black in an infrared image. This characteristic was used with the multispectral images (2004, 2007, 2011 and 2015) to better detect if the pools are to be mapped as indoor or outdoor swimming pools. The right swimming pool in Fig. 2 is an indoor swimming pool and because of the coverage the infrared wavelengths cannot be absorbed. The swimming pool does not appear black and as a result is mapped as an outdoor swimming pool. Furthermore this characteristic was also used to better differentiate trampolines and round swimming pools.

Fig. 2: RGB image (left) with swimming pools and infrared image (right) where outdoor pools appear as black shapes due to absorption.

As stated before the images were not always taken in or approximately in the same month, which especially turned out to be a problem for the mapping of the year 2015. The image was taken in spring, which leads to the assumption that not all pools were already built or set up. This can be seen in Fig. 3. On some places where there was a swimming pool in 2011 but not in 2015 there is a certain structure which exactly fits

the shape of the swimming pool (Fig. 3). If this was the occasion the swimming pool was still mapped as one even though it was not to be seen, but a presumption can be made that the swimming pool was built up in the years between as the shape is clearly distinctive and that it will be built up in the future.

Fig. 3: Swimming pool in 2011 and structure of swimming pool in 2015.

These formulas were used to calculate the average water volumes for different shapes:

- Round pools: $V=\pi*r^2*h$; around 13m³ accords to 13.000 litres per swimming pool
- Angled pools: $V=l*w*h$; around 37m³ accords to 37.000 litres per angled swimming pool
- Hybrid pools (mainly oval pools): $V=l*b*h*0.89$ around 26m³ accords to 26.000 litres
- It was not possible to calculate an average water usage for ponds as their shapes and forms are too variable.

3. Results

The constant and rapid growth of the numbers of private swimming pools in the city of Graz can be seen in figure 4. There has been a tremendous increase especially from 1990 onwards. The slight stagnation between 2011 and 2015 could be a result due to the time the image was shot or there really is a cut down in the numbers. This could be verified by looking at the images the next years, as soon as they are available.

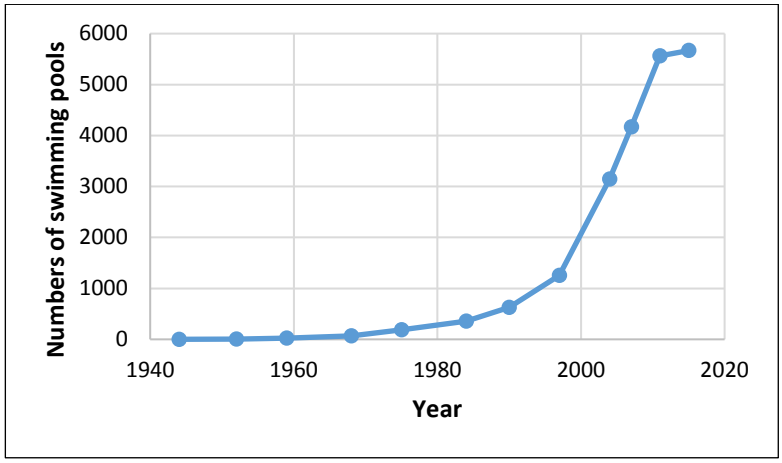


Fig. 4: Numbers of swimming pools in Graz from 1944 to 2015.

In Tab. 3 the total numbers of the swimming pools for all districts and years show that especially the outer districts of Graz have an enormous increase in numbers. The sealing and the building structures in the inner city districts are the reason for the low number of swimming pools as there are few possibilities for construction. This assumption can also be seen in Fig. 5.

Tab. 3: Numbers of private swimming pools seperated by districts and years.

	1945	1952	1959	1968	1975	1984	1990	1997	2004	2007	2011	2015
Andritz	0	0	2	4	21	43	74	167	347	484	695	745
Eggenberg	0	0	1	7	12	18	25	45	118	167	233	252
Geidorf	1	2	5	11	20	34	50	70	141	181	236	253
Gösting	0	0	1	2	2	17	30	64	146	183	262	262
Gries	0	0	1	1	1	4	9	19	61	83	115	110
Innere Stadt	0	0	0	0	0	0	0	0	2	3	4	4
Jakomini	0	0	0	3	3	8	13	19	64	94	146	142
Lend	0	0	0	1	2	2	6	14	3	47	72	70
Liebenau	0	0	1	2	5	12	45	78	249	334	502	492
Maria Trost	0	0	2	8	23	38	58	113	289	390	483	496
Puntigam	0	0	1	3	11	19	37	49	192	293	415	397
Ries	0	0	0	3	11	29	39	75	185	227	282	306
St. Leonhard	0	0	0	0	2	2	5	14	32	40	47	45
St. Peter	0	0	2	4	19	40	74	174	402	496	629	632
Strassgang	0	0	4	4	16	35	68	131	305	418	573	579
Waltendorf	0	1	2	12	25	38	61	148	362	436	502	512
Wetzelsdorf	0	0	0	2	11	18	34	75	218	290	368	370
Total	1	3	22	67	184	357	628	1255	3143	4166	5564	5667

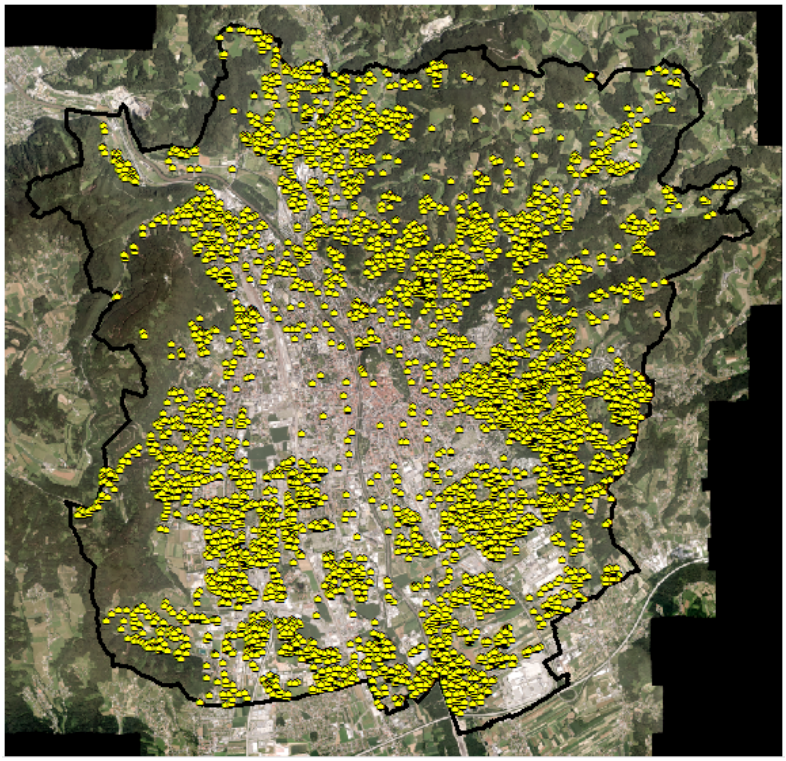


Fig. 5: Distribution of swimming pools in Graz.

To see if the closing of the public swimming place "Pammerbad" in 2004, in the district of St. Peter, had an influence on the increasing numbers in its surroundings some public swimming pools were mapped and then different radiuses over several years were calculated (see Tab. 4). The increasing numbers of the surroundings of the other public places and the Pammerbad were very similar which leads to the conclusion that the inhabitants did not purchase a private swimming pool because the public on in their surroundings closed.

Tab. 4: Number of pools from 1990 to 2011 in a certain distance to a public swimming pool.

Radius of 2 km

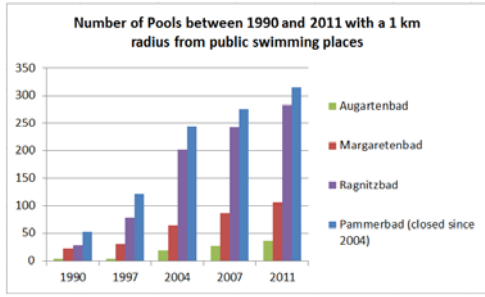
	Pammer-Bad *)	Margareten-Bad	Augarten-Bad	Ragnitz-Bad
1990	134	74	30	116
1997	317	128	48	285
2004	722	292	166	653
2007	877	378	245	778
2011	1035	464	350	911

Radius of 1 km

	Pammer-Bad *)	Margareten-Bad	Augarten-Bad	Ragnitz-Bad
1990	53	22	1	28
1997	122	31	3	79
2004	244	64	18	202
2007	276	86	27	242
2011	315	106	37	283

Radius of 500 m

	Pammer-Bad *)	Margareten-Bad	Augarten-Bad	Ragnitz-Bad
1990	12	1	0	7
1997	35	1	0	30
2004	67	5	2	62
2007	77	14	4	75
2011	89	19	5	81



Another aspect is that the distribution of different shapes of swimming pools is connected to a certain spatial distribution between the districts. As can be seen in Fig. 6 round swimming pools are mainly to be found in the southwestern districts of the city of Graz and angles pools mainly in the north-eastern districts. The different social and therefore building structures can be a reason for this spatial distribution. In the north-eastern parts of Graz the very rich population with big estates have their home. Angled pools are most of the time pools that are built into the ground and they are bigger than the round ones and thus more expensive. If considering that the wealthier population, with bigger parcels, lives in the north-eastern parts of Graz, this could be an explanation for the higher occurrence of angled swimming pools there. In the southwestern parts there are also mainly family houses with gardens to be found but the spatial distances between the houses and the parcels are much smaller than in the north-eastern part which could be an explanation for the existence of the bigger number smaller and cheaper swimming pools in these parts.

The approximate amount of water volume that is used the swimming pools of Graz is shown in Tab. 5. In Graz the amount of angled and round swimming pools in 2011 is about the same. The amount of water used by angled, even though there are as much

as round ones, is about 3 times bigger than by round ones. The approximate total water volume of all private swimming pools of Graz, ponds excluded, is about 139 Million Litres. The Federal Ministry of Agriculture, Forestry, Environment and Water Management states that owning a swimming pool increases the water consumption due to filling and refilling clearly. It can be said, that there is an increase of 40 litres per inhabitant per day (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, 2012).

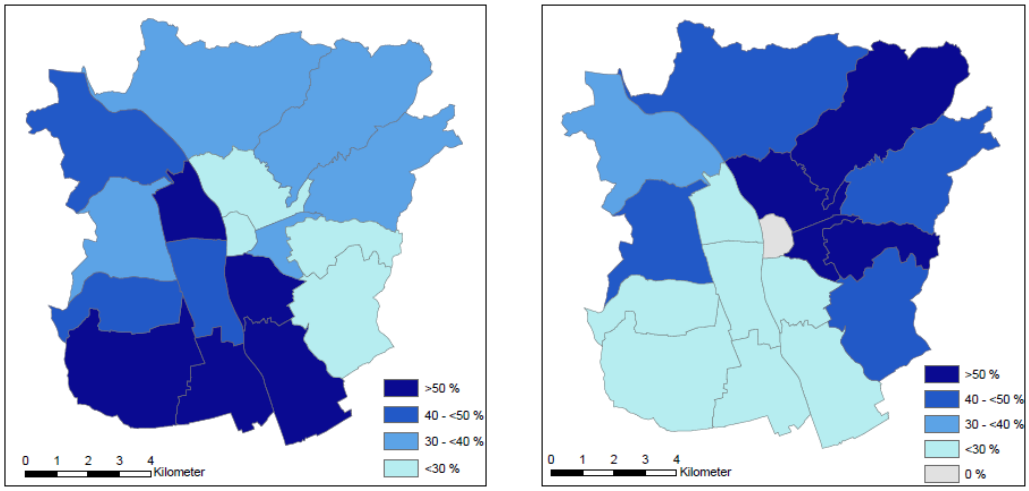


Fig. 6: Relative distribution of round (left) and angled (right) swimming pools seperated by district.

Tab. 5: Numbers of pools seperated by shape and their volumes.

	Pond	Round	Angled	Hybrid	Total
Andritz	38	248	277	132	695
Eggenberg	2	92	109	30	233
Geidorf	8	57	147	24	236
Gösting	6	121	84	51	262
Gries	4	57	31	23	115
Innere Stadt	0	1	0	3	4
Jakomini	4	74	40	28	146
Lend	2	43	15	12	72
Liebenau	12	262	117	111	502
Maria Trost	30	146	247	60	483
Puntigam	8	212	104	91	415
Ries	15	93	119	55	282
St. Leonhard	0	14	28	5	47
St. Peter	36	181	293	119	629
Strassgang	18	299	131	125	573
Waltendorf	26	108	297	71	502
Wetzelsdorf	16	157	108	87	368
Total	225	2165	2147	1027	5564
m^3		27206	78902	26324	139004
L		27206192	78902250	26324064	139004245

4. Conclusion

Private swimming pools have a high rate of water consumption which is the reason why the aspect of the numbers and their usage should be investigated to be able to create sustainable and healthy rules for the environment and their users. Further analysis can be made in regard to the sociogeographic distribution of private swimming pools, for the requirements if water supply and disposal and further investigations on the spatial and temporal distribution. Regarding the city of Graz it would be interesting to look at the development in the following years if the raise in numbers still continues or slowly starts to break down. Another interesting aspect would be to see if the results gained in this study correlate with the experiences of the water suppliers.

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Summary

Private swimming pools have a high rate of water consumption which is the reason why the aspect of the numbers and their usage should be investigated to be able to create sustainable and healthy rules for the environment and their users. To get an overview about the quantities of private swimming pools in the city of Graz this survey was conducted actual and historical aerial images. A swimming pool cadastre from 1944/45 to 2015 for Graz was created, to be able to approximately quantify the used water amount.

Data basis for this study were orthorectified images of Graz from 1944/45 to 2015. Due to the usage of heterogeneous data, from panchromatic orthorectified images to multispectral images taken with UltraCam, the mapping of the swimming pools was done visually. The constant and rapid growth of the numbers of private swimming pools in the city of Graz can be seen. There has been a tremendous increase especially from 1990 onwards.

Another aspect is that the distribution of different shapes of swimming pools is connected to a certain spatial distribution between the districts. The different social and therefore building structures can be a reason for such spatial distribution. In the north-eastern parts of Graz the very rich population with big estates have their home. Angled pools are most of the time pools that are built into the ground and they are bigger than the round ones and thus more expensive. If considering that the wealthier population, with bigger parcels, lives in the north-eastern parts of Graz, this could be an explanation for the higher occurrence of angled swimming pools there. In the southwestern parts there are also mainly family houses with gardens to be found but the spatial distances between the houses and the parcels are much smaller than in the north-eastern part which could be an explanation for the existence of the bigger number smaller and cheaper swimming pools in these parts. Further analysis can be made in regard to the sociogeographic distribution of private swimming pools, for the requirements if water supply and disposal and further investigations on the spatial and temporal distribution. Regarding the city of Graz it would be interesting to look at the development in the following years if the raise in numbers still continues or slowly starts to break down. Another interesting aspect would be to see if the results gained in this study correlate with the experiences of the water suppliers.