After the Disaster –Cadastral Processes to Reestablish Legal Security

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Key words: Cadastre, Disaster, Process, Legal Security, Boundaries

SUMMARY

One of the major problems of a cadastre is a changing reality. Natural disasters typically cause such changes and a problem in the aftermath is the missing legal security for land owners and other holders of land rights. This uncertainty has a direct influence on the rebuilding process after a disaster because it restricts the motivation of land holders to invest money on the improvement of land and it limits the possibility to lend money from banks.

In the paper we show the situation in Austria. The first step is to identify possible disasters for Austria. Previous disasters are discussed and their effects on parcel boundaries and the geodetic control network are analyzed. Realistic disasters include floods, mass movements, and earthquakes. Then the technical and legal concepts to restore parcel boundaries are explained and the problems identified. Objectives for the proposed solution are developed based on different types of disaster. In the conclusions a general idea is presented that could be the basis for the creation of a new method of recovery. It is based on the concept of rural land readjustment, a process developed to enable agricultural predictability.

ZUSAMMENFASSUNG

Eines der größten Probleme von Katastersystemen ist die Änderung der Realität. Eine der Hauptursachen solcher Änderungen sind Naturkatastrophen und die Schwierigkeit nach solchen Ereignissen ist die fehlende Rechtssicherheit sowohl für die Grundeigentümer als auch für die Halter von anderen Rechten an Grund und Boden. Diese Unsicherheit hat eine direkte Auswirkung auf den Wiederaufbau nach der Katastrophe. Unsicheren Grenzen schränken die Motivation der Grundeigentümer zur Investition von Geld ein und Bankkredite sind nur eingeschränkt verfügbar weil auch Kreditgeber Sicherheit benötigen.

Im Artikel zeigen wir die Situation in Österreich. Zunächst werden mögliche Katastrophenszenarien beschrieben und ihre Wirkung auf Grundstücksgrenzen und das Festpunktfeld aufgezeigt. Anschließend zeigen wir die technischen und rechtlichen Konzepte um Grundstücksgrenzen wiederherzustellen und zeigen die vorhandenen Probleme auf. Aus den verschiedenen Arten von Katastrophen werden Zielvorgaben für die zu entwickelnde Methode abgeleitet. In den Schlussfolgerungen wird ein Konzept für neue Methode der Wiederherstellung skizziert. Diese basiert auf der Idee der Zusammenlegungsverfahren, die entwickelt wurden um die Produktivität agrarischer Grundstücke zu erhöhen.

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1. INTRODUCTION

Numerous disasters in the last decades proved that the earth is not stable. Events like earthquakes, floods, tsunamis, or landslides have a serious effect on the terrain. Floods like the major European flood from 2002 cause severe damage to the infrastructure and removes soil from agricultural areas. The economic damage of floods is severe. However, the impact on the extent of parcels is limited. Earthquakes provide a different problem. Earthquakes do not only damage infrastructure and may render buildings unusable, they may also result in significant shifts of the terrain. Landslides create similar changes of landscape. However, earthquakes affect large areas, whereas a landslide is usually a local event. Still, landslides can change riverbeds, obliterate villages, deforest large areas and even change the inclination of a hillside. Effects of most disasters therefore include

- destroyed infrastructure,
- devastated private property, and
- unrecognizable parcel boundaries.

The obvious first steps after a disaster are rescue of people, humanitarian support and recovery of the dead. The next step is the reconstruction of infrastructure: Roads, supply lines, and buildings. Experience from the L'Aquila earthquake (Chiarabba et al, 2009) shows, that disaster response has political, technical, and legal aspect (Alexander, 2010). A major hindrance for reconstruction in L'Aquila are the unclear legal situation (what to do with buildings protected by monument conservation laws) and the unavailability of credits issued to land owners due to the value drop of the property. The cadastre as the basis for definition of land right could support local administration to overcome some of these difficulties. Decisions require information from trusted sources. The cadastre is typically a trusted source, if it is working properly and reflects the real situation. Thus an efficient strategy to match cadastral data and reality is necessary to restart business processes. The goal of this paper is to analyze the situation is a specific country, namely Austria. The Austrian example may trigger an international discussion on legal procedures.

The remainder of the paper is structured as follows: In section 2 we provide an overview on the types of disasters that are relevant for Austria. Section 3 gives a short introduction in the relevant cadastral procedures. In section 4 we show the current solutions and their practical problems both from a legal and a technical perspective. We conclude with some results and a vision for a solution.

2. ADDRESSED DISASTERS

Austria is a landlocked country. Thus disasters like tsunamis are not possible. However, the Alps cover a large portion of the country. The Alps are still being created by plate tectonics and thus there are numerous earthquakes each year. However, the magnitude of most earthquakes is small (for details see section 2.3). Floods and landslides due to heavy rain and strong inclinations are also present in mountainous regions. These three main types of disasters are discussed in the following subsections.

2.1 Floods

Floods are a typical phenomenon of the hydrologic cycle. In cold regions, the runoff varies heavily throughout the year since snow accumulates during winter and melting in spring. Heavy rainfall in other times of the year may also be too much for river beds. Human intervention, e.g., straightening and coating of river beds, exacerbated the situation in many cases. Parameters affecting the intensity of a flooding are amount and intensity of precipitation, size and shape of the catchment area, and the water retention properties of the soil (Patt, 2001, p. 11-14).

The hazard potential of floods is increased by broken rock, debris, and timber carried along. In case of continuous bed load take-up, the flood can even become a mudflow, which has even higher potential to change a landscape (Hübl et al., 2011, p. 20-24).

The water level of rivers varies with the season. Floods happen if the water level exceeds the height of the barriers next to the river beds. The intensity of floods is modelled statistically. A flood that statistically happens once in a century has a higher water level than a flood that statistically happens once in a decade. Nine major floods happened in Austria in the last 25 years. Since 2000, already 2 floods (August 2002 and June 2013) were classified as once in a century. Both were caused by heavy rainfall throughout large parts of central Europe and were not restricted to a specific river. There may be a connection to climate change and some indicators seem to point in this direction but the issue is not yet resolved (Blöschl et al., 2013). The economic damage of the flood in 2002 was 3.2 Bill. € and of the flood in 2013 870 Mill. € (Umweltbundesamt, 2015).

2.2 Mass movements

Mass movements are movements of soil and rock caused by gravitational forces. Typically, these movements are stimulated by natural processes like freezing water, heavy rain, or earthquakes (Glade and Dickau, 2001, p. 42f). The original cause, however, is instability of the terrain itself, which can have natural or manmade reasons, e.g., deforestation. The UNESCO Working Party for World Landslide Inventory created the following classification scheme for mass movements (The Canadian Geotechnical Society, 1993, p. 6-2):

- Fall: Detachment of rock or soil, movement largely through the air
- Topple: Forward rotation about an axis or point below the centre of gravity of the moving mass
- Slide: Movement of masses on surfaces
- Spread: Extension of solid material in combination with a general subsidence into softer underlying material
- Flow: Spatially continuous movement, comparable to a viscous fluid

Movements can be either continuous or spontaneous. Continuous movements provide a severe problem for land owners and cadastral systems because they constantly change shape and position of the affected parcels. This cannot be modelled in a static way. Therefore, the focus here lies on sporadic movements where the boundaries before and after the disaster are static. The web service[1] of the Geologische Bundesanstalt shows that there are thousands of incidents although the data are restricted to events mentioned in analogue media (newspapers or scientific journals, since 1850) or in internet resources (since 2005).

A major mass movement was the fall at the Eiblschrofen in 1999. Approximately 150,000 m^3 rock detached from their foundation and moved towards the village of Schwaz. One effect was the blocking of the Starkenbach on a length of 600 m which could have resulted in a change of the riverbed. Figure 1 shows the effect of the fall on the mountain.

Figure 1: The Eiblschrofen in 2006 (Source: Wikipedia, picture taken by J. Hummel)

2.3 Earthquakes

Earthquakes are a result of plate tectonics. Whenever plates do not glide smoothly but get jammed, energy builds in the rock structure. As soon as the energy exceeds the stability of the material, an abrupt movement of the rock happens. This triggers pressure waves that travel through the earth and the result is an earthquake.

[1] http://gisgba.geologie.ac.at/gbaviewer/?url=http://gisgba.geologie.ac.at/ArcGIS/rest/services/maps/MS_MASS/MapServer

From a tectonic point of view, Europe is far from stable. There are both, plates sliding along each other, and plates under pressure from different directions. Thus numerous earthquakes happen in Europe. Fortunately, most of these earthquakes are not very powerful. The strength of earthquakes can be measured in different ways. The magnitude is determined by the amplitude of the seismometer during the earthquake and typically refers to the Richter scale. Recent earthquakes in Austria had magnitudes of up to 5.3 (in Seebenstein, 1972, ZAMG-Homepage). Since the highest possible magnitude of an earthquake depends on the length of the movement area between tectonic plates, a magnitude of approximately 6 is estimated as a theoretical maximum. Such an earthquake can already destroy well-built buildings. The experience in New Zealand also shows that an earthquake with such a magnitude can cause extensive land and property damage including significant horizontal shifts of physical boundary marks (Grant et al., 2014).

The Austrian geophysical monitoring organisation ZAMG registers approximately 600 earthquakes per year with an epicentre in Austria. Figure 2 shows the distribution of the epicentres. Most of them concentrate in the alpine and southern region of the country. However, it is evident that the Austrian capital city Vienna, which is located in the upper eastern part of the country, is close to an area of high seismic activity. Typically, there are no damages but statistically light structural damage to buildings is expected every 2-3 years, medium damage every 15-30 years and heavy damage every 75-100 years (Suda & Rudolf-Miklau, 2012, p. 48f).

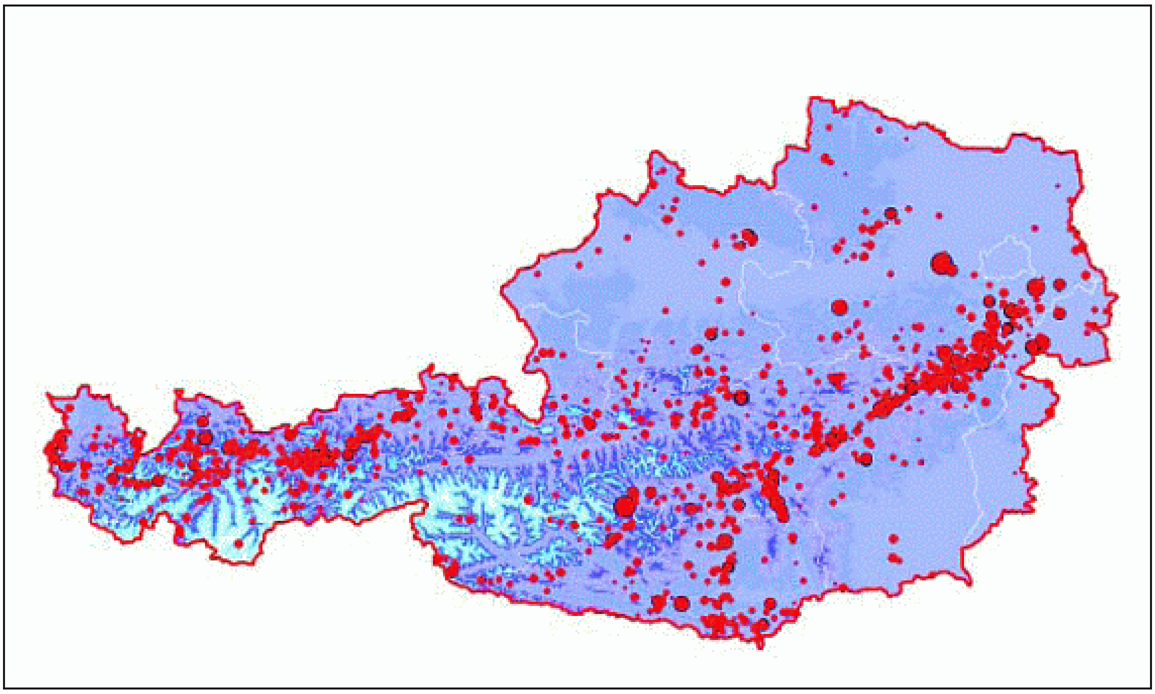

Figure 2 Map of the epicentres of earthquakes in Austria between 1900 and 2011 (© ZAMG, Geophysik)

3. RELEVANT CADASTRAL PROCEDURES IN AUSTRIA

The Austrian cadastral system (Pfahler & Meixner, 2007; Lisec & Navratil, 2014) is map-based, i.e., boundaries are represented in a 2-dimensional coordinate system. This guarantees that the cadastre covers all of the country and there are no overlaps between parcels, which are the smallest pieces of land with a unique identification. A parcel thus has a defined boundary, a size, and for each parcel (or collections thereof), rights can be defined in the land register. The quality of the boundary definition and the area determination depends on the time of the last official measurement of the parcel (typically by a licensed surveyor commissioned by the land owners). In 1968, a coordinate-based cadastre was introduced where the owners of adjoining land agree on the position of the boundary line, which is then surveyed and documented by a licensed surveyor in the Austrian reference system. These boundaries can then be reestablished by any surveyor based on the control point network without the aid of land owners. This is possible because the position of the boundary was defined as a contract between the land owners and any change of the boundary would require a new contract. Of course, this assumes a stable system of control points.

The Austrian system has several possibilities to deal with problems connected to boundaries:

- In absence of boundary marks the boundary may be unrecognizable. If the boundary line (or more specifically, one of the two parcels on either side of the boundary line) is in the coordinate-based cadastre, simply staking out the boundary points solves the problem.

- If the boundary line is not in the coordinate-based system (then called tax cadastre), a discussion between the land owners supported by a licensed surveyors is necessary to define a new boundary. The basis of the discussion is then the results of a survey of the current situation and a comparison to previous surveys. However, the licensed surveyor can only provide expert support, not define the boundary. The definition has to be done by the land owners. If the land owners cannot agree on a boundary line, a court decision can end the conflict where the surveyor may also act as an expert but a judge decides.

- The cadastre can be regenerated for a whole commune if the cadastre is missing or becomes unusable. This happened, for example, after the First World War, when the cadastre was missing or unusable in 185 communes. At this time the result was in the tax cadastre, today it would be in the coordinate-based system. A problem of this procedure is the duration. The regeneration of the 185 communes started in 1928 and was finished in 1963 (Kamenik, 1972).

- A similar process for agricultural areas is the land readjustment (Agrarverfahren). The idea is that agricultural land cannot be used in an economic way, if the parcels are too small or the shape is too fragmented.

The coordinate frame is provided by control points with coordinates in a Gauß-Krüger projection (a transversal Mercator projection with three zones and the reference meridian Ferro) based on the Bessel ellipsoid. The reference frame was developed and originally surveyed by the mapping division of the Austrian-Hungarian military (MGI). Today, the Federal Office of Metrology and Surveying (BEV) is responsible for maintenance and further development (Otter, 2015, p. 6). Until the early 1990ies, the coordinates of the control points were determined by classical methods (distance and direction) in a hierarchical approach with six quality levels. Later, new technologies, e.g., satellite based methods were used as well.

In 2002, Austria implemented a measurement campaign that connected the Austrian system with ETRS89 (Stangl et al., 2003, p. 1-2). In addition, the Austrian Positioning System (APOS) provides correction parameters to determine MGI coordinates with GNSS receivers since 2006 (Otter, 2015, p. 31). The horizontal shift between these two reference systems has a spatial variation and exceeds 2 m in some parts of Austria (Höggerl & Imrek, 2007). The coordinates of the APOS reference stations is EUREF-Class A, i.e., reproducibility with less than a centimeter (Otter, 2015, p. 31). Currently the BEV is working on the homogenization of the control point network, which shall be finished in 2019. Then it should be possible to re-establish every control point with centimeter accuracy. Once the control points are established, the boundaries can be reconstructed (in the tax cadastre) or reestablished (in the coordinate-based cadastre).

4. SOLVING THE SITUATION

A problem of all cadastral processes discussed above is the duration. These processes are designed to provide optimal results for the land user, i.e., the discussions shall guarantee that the intentions of the land user and the legal requirements are met. However, time is of essence for disaster recovery. Damaged buildings will suffer from environmental stress if they are not repaired. However, land owners face a dilemma:

- Land owners do not know the decision by juridical bodies: Buildings may be rated as unsafe resulting in forced destruction or areas may be reclassified as hazardous areas. Buildings under monument conservation provide even more problems since they have to be restored to their original condition even if the costs exceed the value of the building by far. A Viennese example for such a situation is the concert hall, which was destroyed by fire in 2001. Only the facade and walls of the building survived but monument conservation was not terminated and it lasted until 2013 to find and implement a concept for a new building with a new useage (Wikipedia, 2015). As a result, the land owners do not know the legal conditions for further use of the property.

- Boundary marks delimiting the property may have been eliminated or removed by the disaster. Although these marks can be reestablished, this process takes time. Local surveyors—even if they were not affected by the disaster—may be unable to cope with the workload required in the area. Unclear boundary definitions may prevent improvements because it is unclear if a new construction is on the private property or the neighbor’s land. This will stop land owners from investments in their property.

- Repair costs more money than land owners typically have available in cash. Thus mortgages will be required to start the repairs. However, the maximum mortgage is specific percentage of the property value. Since the building typically represents a significant percentage of the value, the mortgage may be lower than necessary.

4.1 Floods

Floods damage boundary marks and indications for boundaries, e.g., walls and fences. The same is true for control points. However, the loss of control points during the flood in 2002 was comparable to losses caused by construction work in villages. A problem in the aftermath of this flood was that the lost control points were not yet defined in ETRS89. Therefore, other control points had to be used and the network distortions caused by the technological limitations in the 19th century made the reconstruction more difficult. In 2002, APOS could not be used because it was not allowed as a sole means to define the geodetic datum. This changed in 2012, when the new surveying decree became effective (VermV, 2010).

The legal consequences of floods are more difficult. A flood implies that a water body exceeds its normal boundaries. The force of flowing water may change the river bed significantly and this may have an effect on the boundaries of private property. The legal basis is written down in the laws pertaining to water and waterways (WRG, 1959). Current legal practice defines the boundary of a water body by the recurring highest water level (Twaroch, 1991). However, the Austrian law distinguishes between ownership of the water body and ownership of the land where the water body is located. Public water bodies can therefore cross private property and the positional change of the water body does not automatically create a change of land ownership. However, the owner of the land would not be able to use his land and technical measures to push the water body from his property would be illegal if not sanctioned by the water authority. Easements located in these areas are affected in the same way. A right of way, for example, could be blocked by the water. However, there is still the claim that the easement is fulfilled. This needs to be settled outside of the cadastre in a civil law agreement. The situation is different for a continuous change of river banks where the Austrian Civil Law Code (§ 404ff, ABGB) uses Roman Law to deal with ownership acquisition by growth. Thus a continuous change of the river bed cause corresponding boundary shifts whereas spontaneous changes do not. However, in case of a spontaneous effect, land owners are entitled to demand compensation. Boundaries defined in the coordinate-based cadastre are not affected.

The current legal procedures seem to be sufficient. The recent floods did not lead to problematic ownership situations. Only in the case of a major riverbed change, the boundaries should be adjusted to avoid conflicts between the public ownership of the water body and the private interest in using the land. Land covered by the water body could be swapped with land freed by the water body to compensate land owners. However, since natural features like rivers do not obey administrative regions, such a process should not be restricted to an administrative region. In addition, the quality of the land should also be taken into account, e.g., by compensation payments.

4.2 Mass Movements

The reconstruction of the control network after a mass movement follows the rules discussed for floods in the last section. The major difference is that most of the control points in the affected area will be lost or unusable. Therefore, movements with a large spatial extent will require establishing a new control network.

The reconstruction of boundary points is possible by using the ETRS89 coordinates of the original control points. The legal aspect of such an event is not regulated. Legal practice uses the definitions for continuous change of water bodies. This is applicable for small movements. Large movements, however, cannot be resolved by this approach. For small movements land owners are entitled to retrieve soil that has been moved to neighboring parcels within a year. However, in many cases this is not economically feasible and the land owners waive the claim. This concept is not applicable for large areas because in the technical realization in the time limit is impossible (Ganner, 2001). A solution for the problem would obviously be that property is not fixed in space and a disaster can shift parcel boundaries. This, however, would contradict the basic idea of the coordinate-based cadastre that boundaries can be described mathematically and are static. This issue is addressed by a change in the law for surveying (VermG, 2016, § 32a) that allows parcels to be removed from the coordinate-based cadastre. However, it not yet defined on a technical level when the rule shall apply.

Technically, the reestablishment of parcel boundary after mass movements is preceded by the decision if the old boundaries should be restored or a new determination is feasible. The method of correction of boundary ("Grenzberichtigung") is available for the new determination of boundaries in the tax cadastre. The method reestablishes the correspondence of reality and cadastral data, which was compromised by the change of reality. There is no corresponding method for the coordinate-based cadastre because changes in reality do not create changes in the ownership situation. A regeneration of the cadastre could solve the problem but is only possible for a commune as a whole. Typically only a part of a commune will be affected by a disaster but it is not possible to restrict the regeneration to a specific region. Thus, the only legal procedure is the action of trespass ("Eigentumsklage"). However, one of the prerequisites is that the land is in possession of the neighbor. This is not the case if the neighbor is currently living somewhere else because his house is uninhabitable.

A suitable cadastral process should enable the legalization of ad hoc solutions for infrastructure. A major road destroyed by a mass movement should be reconstructed as quickly as possible. This could require a different route and would thus cross private property. However, public interest should be higher in the immediate reaction to the disaster and the affected land owner could be compensated later, either financially or by compensation areas.

4.3 Earthquakes

Again the technical reconstruction is based on the principles shown in the section on floods. ETRS89-coordinates of the control points allow reestablishing a network of control points. Starting from these points the boundaries can be reestablished. It cannot be ruled out that APOS itself is affected by the earthquake but in general the reconstruction of control points and boundaries is possible, although possibly with slightly lesser quality than under current conditions.

A major difference between earthquakes and mass movements is that a realistic result is a shift of the earth's surface of some decimeter relative to a neighboring part of Austria. Technically, the shift is no problem in both areas. Parcels overlapping the fault would need special treatment. The concepts from New Zealand (Grant et al., 2014) could provide a solution for this problem. The solution should be transparent, timely, cost efficient, and result in minimal boundary disputes (Robertson et al., 2016).

In the tax cadastre the solution could be to apply the concept of undisputed possession: A fence that served as a boundary line for years defines a boundary. A fence crossing a fault will be undamaged on both sides of the fence providing a clear boundary line. Thus only the short section crossing the fault needs to be discussed.

The coordinate-based system requires a transformation with separate parameters for each side of the fault to match the new coordinates. However, this would contradict the idea that changes of reality do not create changes in the boundary. Thus, it may be necessary to create a new law to deal with the situation. New Zealand used this strategy by establishing the Canterbury Earthquake Response and Recovery Act 2010, which had only temporal validity (Smith et al., 2011, p. 11f).

5. CONCLUSIONS

In the paper we discussed three types of disasters that may happen in Austria. We showed the technical and legal possibilities and difficulties in the reestablishment of cadastral correctness and legal security. Typically, the technical problems can be solved by storing coordinates in the ITRS because this international reference system should not be harmed by local events. A problem in Austria is the concept of static coordinates, which assumes that boundary changes are a result of human intervention. The concept has benefits in stable situations because it limits discussions, boundary disputes, and objections to boundary reconstructions to an absolute minimum. However, it has problems when the earth is not static. Thus, a solution for this event is necessary. The fact that rivers do change their course has had an effect on laws so the idea of a changing reality is not new in the Austrian legislation. The concepts just need to be merged in a legally and technically sound way.

A process is required that provides legal security (at least regarding ownership and easements) and determines clear parcel boundaries, thereby securing the investments of the owner. The following properties could be claimed:

- It should be simple, fast, and efficient.
- It should support the reconstruction of public infrastructure even if it needs to be relocated.
- It should be done for the area affected by the disaster and not be hindered by administrative boundaries (unless it is national boundaries).
- It should be fair to all land owners.

The process could be based on the idea of land readjustment (which is done for rural areas) because it would allow readjusting the geometry of the boundaries and at the same time creating space for new infrastructure if necessary. Sweden is currently using a similar approach to deal with the results of a forest fire from 2014 (Ersbo and Land, 2016). However, implementing this kind of concept in Austria would need further development, detailed discussion, and experiments based on good examples.

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