



DROUGHTS, DRY SPELLS AND LOW WATER LEVELS IN MEDIEVAL HUNGARY (AND CROATIA) I: THE GREAT DROUGHTS OF 1362, 1474, 1479, 1494 AND 1507

Andrea Kiss^{1*}, Zrinka Nikolić²

¹Institute for Hydraulic Engineering and Water Resources Management, Vienna University of Technology,
Karsplatz 13, 1040 Vienna, Austria

²Department of History, University of Zagreb, Ivana Lučića 3, HR-10000 Zagreb, Croatia

*Corresponding author, e-mail: kiss@hydro.tuwien.ac.at

Research article, received 22 January 2015, accepted 23 March 2015

Abstract

In the present paper five significant late medieval drought events, occurred in Hungary (4 cases) and Croatia (1 Dalmatian case), are discussed based on contemporary documentary evidence. Information on long-term lack of precipitation, severe annual (or multianual) water shortage, extreme low water levels of major rivers or bad harvest and severe food shortage in 1362, 1474, 1479, 1494 and 1507, often accompanied or followed by locust invasions, were documented both in narratives, account books, charters and letters. Apart from causing food shortage or difficulties in transportation (e.g. of salt), these greatest known documented drought events of medieval Hungary were blamed for weakening the country's military defence (e.g. low water levels) and providing good opportunities for Ottoman-Turkish attacks. These great drought events sometimes occurred one year later than those of the neighbouring areas in Central Europe – a fact that can be probably explained by the bi- or multi-annual nature of dry spells (e.g. in and around 1474, 1479, 1507) that does not necessarily fit the frame of a calendar year.

Keywords: droughts, dry spells, low water levels, food shortage, medieval Hungary and Croatia

INTRODUCTION

Drought is one of the most significant natural hazards in Hungary as well as in most of the Carpathian Basin (e.g. Pálfi, 2004), and this is especially true for historical times (see e.g. Pálfi, 2009; Kiss, 2009; Vermes and Pálfi, 2007). In medieval Hungary direct information on drought events is available only in a few cases. These few cases, however, may provide precious examples on how severe droughts effected late medieval socio-economic conditions, and also on the society's reaction (e.g. weak harvest, tax reductions, special actions/permissions of authorities, effects on military operations). They become even more apparent when comparing to other countries, for example, in the Central European region. Another interesting point is that most of the known medieval drought events appeared in combination with other reported natural hazards (e.g. heat and devastating hails: 1507, locust invasion: 1474–1479).

In the recent decade regional overviews, including the Middle Ages were published concerning the Czech Lands (Brázdil et al., 2013), Germany (included in: e.g. Glaser, 2008), for the Eastern Alpine region (included in: Rohr, 2007 – medieval extremes). For the last 500 years, for example, in the discussion of low water levels of the Upper-Rhine by Pfister et al. (2006) in Switzerland, or about the droughts occurred in Spain (e.g. Domínguez-Castro et al., 2008). In the context of a famous historical drought, recently the most well-known early modern case,

the 1540 drought event – which otherwise was also combined with great heat – was discussed on a European scale (Wetter et al., 2014).

The term 'drought,' with clearly indicating serious water deficit for a longer period of time, can sometimes have slightly different meanings: meteorological drought, hydrological drought, agricultural and socio-economic drought have their own definitions in the different disciplines (e.g. Heim, 2002; Pálfi, 2004; Brázdil et al., 2013). In historical documentary evidence one can often find descriptions referring to drought either in its agricultural drought (i.e. affecting harvest and food production), or in its hydrological drought (i.e. referring to conditions of water bodies, e.g. groundwater level in wells, water levels of lakes/water flows) meanings. Due to its importance in food supply, agricultural drought usually plays an important role in historical documentation (e.g. 1362, 1507 in our present cases), but hydrological drought – with problems in using (or not being able to use) major water flows (1494) or in military operations (e.g. 1474, 1479, 1494) as well as shortage of water supply (1362, 1507) – can also rather often appear in historical documentation. Socio-economic consequences of great droughts can be followed practically in all of our five studied cases.

Henceforth, despite relatively scarce documentation on the topic, we can clearly identify some extraordinary great drought events in the countries of the Hungarian crown; such cases were, for example, documented in 1362, 1474, 1479, 1494 and 1507. The inclusion of the

later date (1507) in discussion is due to the Hungarian termination of the end of the Middle Ages (1526). These occurrences are also interesting because reports about the five great drought events remained at least in four different sources types: while the 1362 and 1494 cases are preserved in charters, the 1474, 1479 and 1494 examples remained in a contemporary chronicle, the 1507 great drought event (and some of its consequences) was reported as contemporary inscriptions in an Almanach (notes of a Buda citizen), and an extensive set of information was also included in an economic-administrative source, the account books of the bishop of Eger (his administrator's accounts). Thus here, as a first paper on the topic, examples are provided when clearly great drought events were reported in contemporary medieval documentation.

LATE MEDIEVAL DROUGHTS AND DRY SPELLS IN CENTRAL EUROPE AND BEYOND

For the better understanding of the studied cases, it is worth to have an overview on the medieval-late medieval dry spells and droughts known from the surrounding areas. Due to the fact that some studies and published evidence in this topic are already available for the Eastern Alpine region, the Czech Lands and for Poland, it is also possible to discuss some parallels between the Carpathian Basin and its immediate neighbourhood.

In the Eastern Alpine region, based mainly on contemporary narratives and partly also on other (e.g. charter) evidence, some of the years with droughts or longer dry spells and water deficit (often combined with mentioning heat), documented in 13th-early 15th-century reports, were included in the book of Christian Rohr (2007) 1244, 1255, 1262, 1276, 1277, 1307, 1311, 1312, 1313, 1360, 1394, (1401, 1356, 1425 – suggested by Glaser, 2008), 1426, 1427, (1473 – suggested by Brázdil and Kotyza, 1995) 1503, 1513, 1514. In case of Austria, drought in reports is often combined with an extensive loss of domestic animals, for example in 1277, 1360, 1394, 1426, 1427, while sometimes drought is followed (or accompanied) by reports on food shortage or hunger (e.g. in 1255 in Austria, or in 1312, 1313 in the Czech Lands, Austria and Bavaria (e.g. Brázdil and Kotyza, 1995; Rohr, 2007) as well as urban fires (e.g. 1244 in Austria: Rohr, 2007). It is interesting to conclude that, concerning our discussed late medieval drought events, currently we find almost no parallels in known medieval Austrian documentation (only 1473: on year earlier than reported for Hungary).

In the Czech Lands, based on various types of contemporary source evidence, shorter or longer periods of dry weather and/or drought events were identified in the following years: 1091, 1121, 1128, 1177, 1194, 1252, 1260, 1262, 1266, 1283, 1307, 1312, 1315, 1326, 1328, 1333, 1334, 1337, 1348, 1352, 1368, 1369, 1371, 1393, 1423, 1425, 1432, 1441, 1442, 1461, 1469, 1471, 1473, 1476, 1480, 1482, 1501, 1503, 1504, 1506, 1509, 1512, 1513, 1516, 1517, 1518, 1520, 1525 (see Brázdil and Kotyza, 1995; Brázdil et al., 2013: Table 1 and Fig. 3). In the Czech Lands, with regards to our study period,

especially the 1500s and 1510s stand out with 5-5 years of considerable dry periods reported in a single decade, while the 1260s, 1330s and the 1470s with 3-3 cases per decade are also rather significant. This list, containing any dry-weather information found by the authors concerning the Middle Ages, provides further information concerning our examples: in connection with the listed drought years in Hungary and Croatia, it seems that 1473 and 1506 (thus, one-one year before our great drought events), and 1480 (one year after our great drought case) were reported as years with dry spell or drought in the Czech Lands.

According to the weather event data collection for Poland (containing references up to 1500: Malewicz, 1980) based on narrative evidence dry spells, droughts or low water levels were documented concerning the years 1322, 1332, 1361, 1379, 1442, 1448?, 1451, 1452?, 1455, 1459, 1461, 1463, 1467, 1468, 1469, 1473, 1474, 1475. However, from a contemporary report (by Marcin Biem) it is also clear that 1494 was an important drought year, too (Limanówka, 2001). Thus, based on the currently available medieval Polish evidence the 1450s, 1460s and 1470s have the most importance; and the year of 1361, and both 1474 and 1473, 1475 (i.e. the years before and after) are also mentioned as years with significant droughts. Both from the viewpoint of Dalmatia, Croatia and Hungary, documentation related to the Central and East-Mediterranean areas of Europe (or the region east to us) would have great further importance. However, no studies have been carried out so far on the Italian) droughts, and we find no parallels of the discussed events in the Greek medieval weather-related investigations either (e.g. Telelis, 2008).

As we can see, the years with shorter or longer dry periods, discussed in the present study, sometimes have parallels in the neighbouring areas, but in most cases currently there are no direct parallels known from the areas closest to the Carpathian Basin. Nevertheless, this is also true when comparing the available documentary evidence of the neighbouring areas to each other. On the one hand, this is clearly due to the differences in climatic conditions and the great territorial variability of precipitation; on the other hand, it also depends on the quantity (and type) of the related available documentary evidence. Consequently, while even less significant dry spells might have been reported in some years well covered by sources, sometimes even a great drought event may have remained forgotten due to lack of sufficient documentation. Based on our present knowledge, this is also true for the Carpathian Basin where both the great territorial variability of precipitation (also of precipitation extremes) and the uneven spatial and temporal coverage of documentary evidence may prevent the detection of most dry spells and droughts occurred in the Middle Ages.

Looking around in the broader neighbourhood, multiannual drought periods were documented in the East European Plain both in the early 1360s and the early 1470s (e.g. Klimenko and Solomina, 2010).

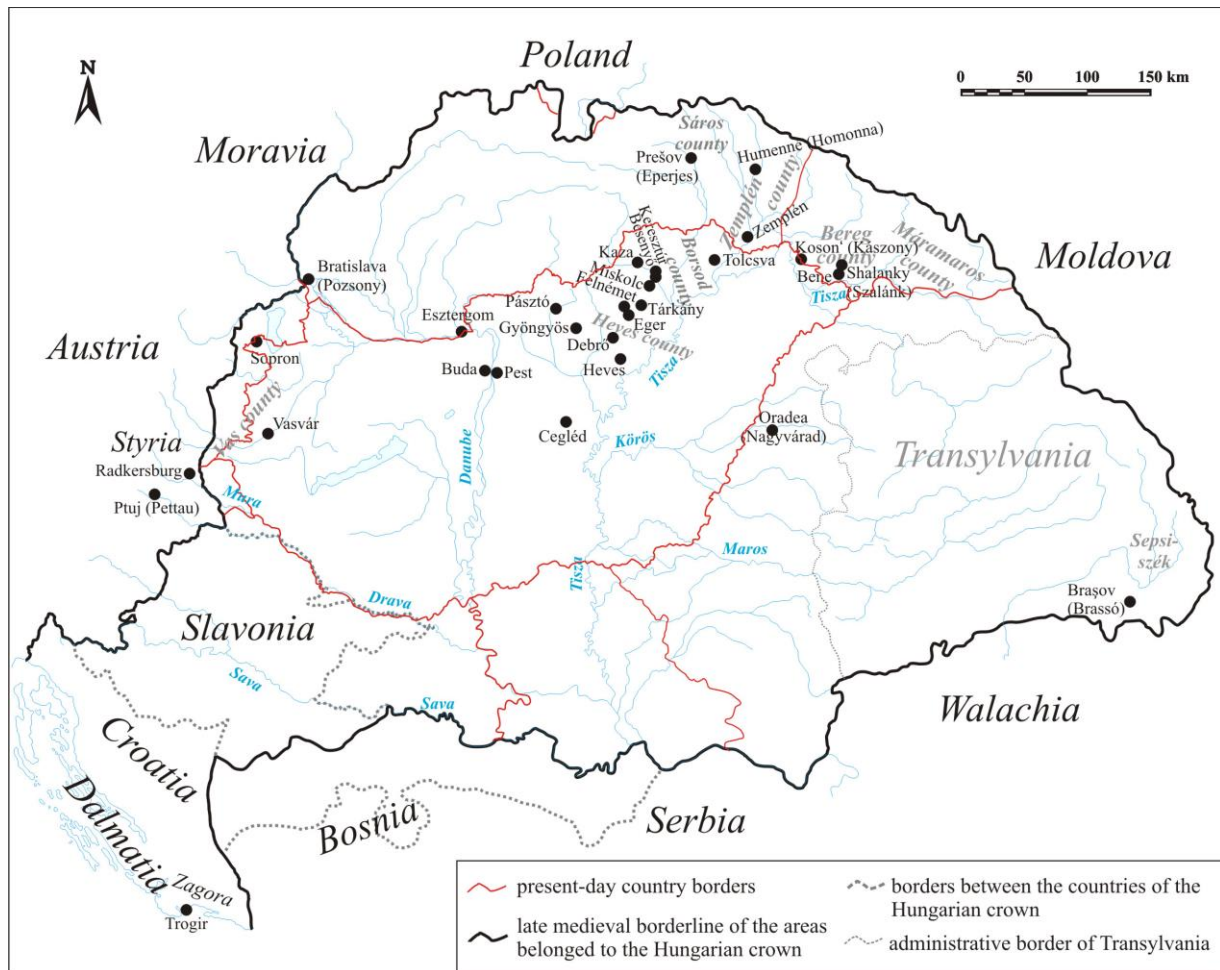


Fig. 1 Locations in late medieval Hungary, Croatian kingdoms and Austria, mentioned in the present study (historical settlement names in brackets)

Concerning the German areas (esp. the southern and central parts), in parallel to our discussed case studies, Glaser (2008) suggests that summer drought occurred in the years 1473 (also in 1471, 1472), 1479 (and the year before) as well as in 1506. As for spring droughts both 1479 and 1507 are listed among the drier years; additionally, the autumn was also suggested as dry in 1507.

As we can see, our case studies have some parallels in Central Europe with special emphasis on the areas west, north and northeast to the Carpathian Basin. Unfortunately, at present little is known in the topic concerning the areas south and east to the Carpathian Basin, except for the early 1362 drought evidence referring to Trogir at the Dalmatian coast (for locations, hereafter see Fig. 1). However, since at that time Trogir – with large part of Dalmatia – also belonged to the Hungarian crown, this case is included in the present paper in more detail, and is discussed in the next chapter.

SPRING 1362 IN DALMATIA: DROUGHT AND DUKE'S GRAZING PERMISSION

The first drought evidence, discussed in the present paper, is not from Hungary or the Carpathian Basin, but from Trogir (Trau) at the Dalmatian coastline. On 25 March (2 April in

Gregorian Calendar – hereafter GC) in 1362, the duke of Dalmatia and Croatia (*banus*) gave permission to a pastoral community called *gens Morlachi* (the so-called 'Black Vlachs') to stay with their animals within the boundaries of the town of Trogir until the day of Saint George (24 April; GC: 2 May), because of the great drought (ed.: Smičiklas et al., 1915; Fejér, 1834). This special (and rather exceptional) permission was issued by the duke (ban) of Dalmatia in the name of the Hungarian king especially because of the great drought. The permission was given in order to avoid the mass extinction of their animals which formed their predominant property (and incomes); as suggested in the charter, particularly the young lambs were in danger of death ("*..., tamen quia emporis nimia siccitas et onerosa nunc ad presens in tantum imminebat, ac etiam agnellorum teneritas a loco ipsius habitationis remoti fuissent in maximum damni periculum incidi potuissent,...*"). Thus, in the Dalmatian Zagora area, due to the drought, there was not enough water and grass to feed the animals (even on basic level).

This fact indirectly also indicates that the situation at that time was not so severe along the seashore as in the hinterlands, in the surrounding (limestone) mountain area (Zagora): Morlachs temporarily could stay in a piece of land in the Trogir area where fresh water was also available for their animals. The dating of the charter (25 March in Julian Calendar – hereafter JC) as well as the duke's permission suggest that at least the usual winter–early spring pre-

precipitation was missing in (late) 1361–1362. For us the most important information is that, according to the contemporary eye witnesses, at that time great drought prevailed, and it had already lasted long enough to have clear threatening signs that forced Morlachs to leave their territory and go into a clear conflict by entering (using, and causing damages in) the lands of Trogir. Additionally, the wording "in those times" may allow thinking in a broader time frame of months concerning the severe water deficit in the area. As the Morlach shepherds were allowed to stay with their animals only up to 24 April (GC: 3 May), this fact may indicate the protection of belongings before the taxation date (day of St. George); but also that they hoped for some April–May precipitation.

As we can see, beyond mentioning great drought in early–mid spring time, the case has some further interesting social consequences: the pastoral community had to leave and go beyond its usual grazing territory, and entered the (prohibited) territory of the town of Trogir. This caused controversies with the citizens of Trogir that a decision and an exceptional solution (and guarantee), with reference to the special environmental conditions, were needed from the highest legal-political authority (duke and the king). Thus, not only the terminology but also the following special legal solutions suggest the extraordinary nature of the drought event.

A probable further interesting (although some later) contemporary information from Hungary is that, according to the protesting charter of the canon and bishop of Veszprém against the parish priest of Pest (today E-Budapest) town, the grape harvest of a particular vineyard in the Pest area started in this year rather early, as the tithe was already taken by 22 September (JC; charter edition: Fejér, 1834; regesta: Bártfai Szabó, 1938).

For 1362, no drought or dry spell evidence for this year are available in the Czech or German databases. However, in Austria 1360 was a drought year (Rohr, 2007), and information is available on the great drought of 1361 in the Polish evidence (Malewicz, 1980). Additionally, the years of the early 1360s were also an important multiannual drought period (including 1362) in the East European Plain (e.g. Klimenko and Solomina, 2010). From a multiannual perspective it is also interesting to mention that in the years 1363–1366 locust invasion were reported in Italy (taken by the NE winds, the "vento schiavo temperato" - from the direction of the S-Carpathian Basin; see: Camuffo and Enzi, 1991), in 1364 in Tyrol/Austria and Germany (see Rohr, 2007; Glaser, 2008). Furthermore, central governmental acts organising the distribution of crops were initiated in 1362 in Bohemia (Brázdil and Kotyza, 1995) and in 1364 in Hungary (for charter edition: Fejér, 1834).

Apart from the 1362 charter, problems with Morlachs were further mentioned in other years in the late medieval period, although without referring to any natural hazards as a cause. As discussed by Klaić (1880; 2010) the Morlachs caused problems with occupying areas for grazing or were mentioned in connection with a settling process in charters dated to 1344 (ed.: Ljubić, 1870), 14 December 1357 (ed.: Smičiklas, 1914), 5 November 1383 (ed.: Stipišić and Šamšalović, 1916), 2 November 1387 (ed.: Gunjača and Stipišić, 1981), 17 June in 1402 (ed.: Hrabak, 2010) and in

1465 (ed.: Kukuljević Sakcinski, 1863). Although without possessing any direct (or even indirect) evidence we cannot draw any further conclusions, it is interesting to add that in some of these years longer dry spells were mentioned, for example, for the German areas (Glaser, 2008) in 1344 (summer), 1383 (summer and autumn), and in 1402 (spring). Furthermore, dry periods were reported one year earlier, in 1464 (spring and summer; and also in the preceding years), and in another case one year later: in 1388 (autumn).

THE GREAT DROUGHT OF (1473-)1474 AND SOME POTENTIAL CONSEQUENCES

An extraordinary (multi-)annual drought?

Concerning the year of 1473, extreme dry and hot weather was reported for the Czech Lands. Other sources reporting on the same weather conditions in the entire Poland and many parts of the German areas (for overviews, see e.g. Malewicz, 1980; Brázdil and Kotyza, 1995; Glaser, 2008). Moreover, the contemporary Polish history writer, Jan Długos, himself also mentioned that the unprecedented heat and lack of rain also prevailed in whole Europe (Długos 1877–1878). It is, therefore, somewhat surprising that the similarly contemporary Antonio Bonfini in his very detailed work about Hungarian history did not mention this fact at all, only the drought of the next year. 1473 was the year when King Matthias led military campaigns to Silesia against the Polish king, and the only detail Bonfini noted (apart from the very detailed descriptions of military and political/diplomatic operations) that there was food shortage in Poland and the Polish troops struggled with shortage of food supply, a problem which was clearly not present in the Hungarian camp (ed.: Kulcsár, 1976).

From our point of view, Bonfini's descriptions in Hungary starts to be interesting from late winter, 1474: on 7 February Ottoman troops suddenly crossed the Danube and the Maros rivers, destroyed many settlements, but especially the rich merchant town, (Nagy)Várad (today Oradea in Romania; see also: Florianus, 1884). The quick crossing and appearance of a significant (even if not big) Turkish army in Várad, very far from the Turkish-Hungarian borderline, may suggest cold and dry conditions (i.e. little or no snow) already in late January–early February in the south-east parts of medieval Hungary (see Fig. 1).

However, descriptions on the real drought came later: for this year, Bonfini reported on the great shortage of water ("*Insolita hoc anno aquarum penuria fuit*") and year(s)-long drought – in which springs dried up ("*siccitas perennes quoque fontes exhaustit*") – (ed.: Kulcsár, 1976). Due to this drought, main rivers of the country had very low water levels, and the Ottoman Turkish troops could (again) enter Hungary by crossing the main rivers ("*Turci superato Savo Pannoniam incursarunt*"). Bonfini's dating is clear and correct: the year of these Turkish attacks undoubtedly took place in 1474. Nevertheless, while describing the drought, Bonfini in his text applies the word ("*siccitas perennes*") which has the meaning of the 'entire year', but it may also mean a peri-

od longer than a year. The lack of mentioning 1473 drought in Bonfini's case can also be explained as the author, whose primary interest was on politics and speak in favour of the Hungarian king, simply did not find 'important enough' to mention in more detail the circumstances that weakened the Polish army against Hungarians in the Silesian 'affair', while in 1474 it was rather important to mention the environmental circumstances that clearly helped the Ottoman-Turkish troops in their rather successful military campaigns.

Furthermore, it is interesting to add that 1473, as the year of a great heat and drought in Hungary, is more widespread in the literary tradition of non-contemporary evidence than the 1474 drought itself: for example, in the domestic early 17th-century *Chronica Leibitzeriana* (in the Spiš area), similar to the 17th-century chronicle of Caspar Hain from the same region (Bal, 1910–1913), great heat and drought are dated for the year 1473 (Schmauk, 1889: "MCDLXXIII. Jam magnus calor & siccitas fuit incipiendo a Pentecoste (JC: 5 June, GC: 14 June) usque ad festum omnium Sanctorum (JC: 1 Nov., GC: 10 Nov.), ut silvae a Sole accensae sint, & radices etiam in terra exaruerint."). However, there is no mention of the 1474 drought at either places. Also referred by Antal Réthly in his compilation on weather events (1962), the mid-16th century Swiss polyhistor, Conrad Lycosthenes (1557) similarly reports on the great drought that caused forest fires and rivers drying up in Hungary, and also that even the Danube would have been crossable in 1473, in the year when the king of Cyprus, Jacob (II) died ("Aestate ob siccitatem & aestum nimium sylvae incensae, flumina siccata, ita ut Danubius in Hungaria meabilis fieret. Iacobus Cypri rex obiit, ..."). Still, there is always a possibility that the two 17th-century chronicles took the year (and the information) from the same local German 16th-century source (in general, see e.g. Szabó, 2014), and this is as well probable in case of the mid-16th century German author, Lycosthenes. Therefore, even if it is possible that already 1473 was dry in Hungary, these non-contemporary sources alone cannot be applied to support the idea.

A potential consequence? The great locust invasion in (1473–)1474–1479

A probable consequence of the great drought, affecting large parts of Europe, was the severe locust invasion started in the same years (in Moldova and further) and lasted until the end of the decade. In the Austrian *Continuatio Mellicensis* (ed.: Pertz, 1851), the beginning of a 3-year long locust invasion is dated to 1473: coming from Moldavia, locusts spread over in Transylvania, Hungary, and reached as far as Bohemia and Linz in Austria ("1473. eodem anno et sequentibus tribus locustarum grex magnus et innumerabilis ex Moldavia emersus, per totam Transsilvaniam, Ungariam, usque Bohemiam, et in Austria usque Lincz multa debachatus est."). Locust invasions are usually associated with dry periods; their long-distance travel is strongly connected to specific changes in wind circulation. Locust invasion of Hungary was as well mentioned referring to 1474 in the (Styrian) *Chronicon Anonymi Leobitensis*; in this later case the chronicler specifically mentioned them to be

seen at Esztergom (see *Fig. 1*) located in Central Hungary (as a later, additional note to the early 14th-century part of the chronicle: "Anno 1474 in Hungaria apud Strigonium idem genus locustarum modo quo hic est expressum apparuit."). Both Polish and Czech chronicles mention 1474 as the starting year of locust invasion (Brázdil and Kotyza, 1995). In this case dating of Czech sources is especially interesting because, as the *Continuatio Mellicensis* suggested, the (usual) route of locust invasions led through Hungary, then continued to the Czech Lands, most probably via the Vienna area, and further in the Danube valley, towards Linz.

Similarly, according to the contemporary domestic *Chronicon Dubniciense* (ed.: Florianus, 1884), this locust invasion happened in the same year as the Turkish attack of (Nagy)Várád (today Oradea, Romania), in 1474. Moreover, the same source clearly dates the great amount of locusts to July and August which appeared in such quantity that, except for the leaves of vine stocks and trees, they consumed all green vegetation ("Nec hoc tacendum esse putavi, quod in estate anni predicti signanter in Julio et Augusto mensibus, innumerabiles et incredibilis multitudinis locuste, catheruatim quasi magni montes, per climata et partes dicti regni Hungariae hinc inde volitantes vise sunt; que omnia virencia pro usu earum preter folia arborum et vinearum vendicarunt,.....". See also: Csukovits, 2008).

Thus, the locust invasion most probably started in the areas east to the Carpathian Basin in 1473, and the outbreak in Hungary occurred in the next year, in 1474. Concerning duration of the locust invasion the information is more diverse: the *Continuatio Mellicensis* suggested 3 years (presumably for Austria), Czech narratives referred to 2 years, whereas for Hungary the *Chronicon Dubniciense* claimed that this locust invasion lasted almost/around 5 years. However, taking 1474 as the starting year of the invasion and 1479 as the last year, this invasion lasted for 6 years in Hungary. As we will see, similar to the starting year(s), the last year(s) of this great locust invasion was also famous of its extensive drought.

DROUGHT, LOW WATER LEVELS, TURKISH ATTACK AND LOCUSTS: 1479(-1480)

As described by the contemporary author, Antonio Bonfini (ed.: Kulcsár, 1976), again for the luck of the Ottomans, great drought occurred in early 1479: up to the 7 Kalenda of April (JC: 26 March; GC: 4 April) there was no rain at all ("Fortuna Turci audaciam sequitur fovetque, nam tanta siccitate is annus exaruerat, ut ad VII. Kalendas usque Aprilis nunquam tantum pluerit, quantum sitibundum terre dorsum parumper aspergere potuisset."). Bonfini blamed this winter and early-spring drought for the extraordinary low water levels of the Sava and Drava rivers. The two rivers had so little water that, rather unusually, in many places they were passable. The Drava, that has always been a navigable river, became passable on foot ("Utraque Pannonia Savo hinc et Dravo illinc circumventa Istro munitur et Turcorum

incursum amnes inhihent, pre insolenti vero siccitate Savus in plerisque locis vado transiri poterat. Dravus semper ac ubique navigabilis eo anno pedibus traici passus est; in causa fuit insolentissima siccitas, cum fluvii tres ubique navigentur."). The possibility of an easy crossing provided (again) a great opportunity for some Ottoman Turkish troops to attack Slavonia, West-Hungary up to Vasvár (Castrum Ferreum) and Styria up to Radkersburg in summer, where they caused immense damages ("*Turcus vadi exploratorem invenit ad Dravum, quem multa mercede conduxerat. Transmisso iam Savo triginta Turcorum milia in Dravi repente ripa consedere ac ii tutum vadum edocti superato amne Pannonias invadunt, in pagos, in homines ac pecora iuxta deseviunt, ferro ignique isquequaque debacchantur, ad Castrum usque Ferreum et ad Styriam Rachospurgumque decursant.*").

According to Bonfini, the Ottoman attack occurred in August, when the king and his people were occupied by the country meeting in Olomouc. It is interesting that, even if the Turkish attack occurred in (mid–late) summer, Bonfini blamed the winter–spring drought for the low water levels of the Sava and Drava rivers. Nonetheless, due to the very low water levels, the rest of the spring and summer had to be also dry. In the further understanding of extreme low water level conditions we also have to take into consideration that in the German scientific literature both 1478 and 1479 were mentioned for their dry summers: in 1479 also spring was notably dry in the German areas (Glaser, 2008). In the Czech Lands no such problem is mentioned for 1478, but the summer and early autumn of 1479 were hot and dry. Heat and drought were even more significant, in 1480 (Brázdil and Kotyza, 1995).

About the Turkish attack to Carinthia through Bosnia in August 1478 (JC: ca. 10 August; GC: 20 August) only the many (3000) casualties due the broken Drava bridge (but no drought) were mentioned by the Polish chronicle writer (Długos, 1877–1878). However, Bonfini (as we could see before) explicitly mentioned at the year 1479 that the great drought made crossing and invasion clearly easier for the Ottomans. In the same time, according to the *Chronicon Dubniciense*, in Hungary locusts made the greatest damage in the last years of their stay (since 1474), namely in 1478 and 1479 (ed.: Florianus, 1884: "... et iam admodum multiplicata continuis annis in regno durauerunt, fere quinque annis integris, dampna indicibilia, signanter hoc anno, scilicet millesimo quadringentesimo septuagesimo octauo inferentes, et similiter in anno millesimo quadringentesimo septuagesimo nono.").

Either as a separate case or as a continuation of the 1479 drought, great aridity is also reported by a contemporary source (Gyöngyösi's *Vitae fratrum eremitarum*) in spring 1480, when – fulfilling the king's request – the Paulines of the Budaszentlőrinc monastery carried out a religious procession asking for rain. The rain did arrive during the procession, and refreshed the vegetation (source ed.: Hervay, 1988; see also: Fedeles, 2007).

As a conclusion, similar to the previous 1474 case the very low water levels of major rivers, together with

the consequent Ottoman Turkish attack, were reported to be caused by a prolonged drought. Due to the severity of water deficit, this drought lasted most probably longer than a three-month winter–early spring period, suggested by the contemporary chronicler, and the drought might have continued (maybe in a lesser extent) in spring and most of the summer, too. Furthermore, based on some German parallels we cannot exclude the possibility that the previous year might have been also drier than usual, and (again similar to the case of 1473–1474) the fact that Bonfini did not mention drought for the previous year does not exclude its potential occurrence. Although Antal Réthly, referring to Bonfini, also mentions a drought in 1478, in the works of Bonfini drought is mentioned only under the year 1479 (and not in 1478).

DROUGHT, LOW WATER LEVEL, FOOD SHORTAGE, TURKISH ATTACK IN 1494

The large-scale, half-year drought

A more direct and detailed report of a clearly severe and extensive drought is available 15 years later: as reported again by Antonio Bonfini (ed.: Kulcsár, 1976) in his extensive works, in the year of 1494 there was continuous drought for six months in Hungary ("*Quin etiam tempus maxime idoneum nacti, quod et rex in Transylvanie finibus aberat et perpetua sex mensium siccitas omnes prope amnes, qui Ungarie propugnacula sunt, ita exhauserat...*"). Rivers, that protected Hungary (as well as Croatia and Austria) against Ottoman Turkish attacks, had so low water levels again that it was easy to cross them and thus, in the entire October Turkish troops continued destroying lands in South Hungary and Slavonia, and they also attacked and devastated South-Styria up to Pettau (today Ptuj in NE-Slovenia) ("*... ut multis in locis facile traici vado possent, per totum Octobrem mensem populationes atque indencia usque ad Petoviam perduxerunt.*"). Moreover, since these events were followed by a hard winter in which all rivers were firmly covered by ice, the Turkish troops could return to the Sava river, killing those who were unable to proceed ("*Inde Dravo ad Petoviam traiecto et magnis detrimentis illatis hominum ad septem milia abduxerunt. Post autem metu, ne intumescerentibus sub imminentem hiemem omnibus aquis intercluderentur, ad Savum regressi, quicunque aut etatis aut corporis imbecillitate languoreque sequi non potuerunt, eis capita in ripa fluminis detruncarunt*"). It is an interesting fact that while they easily crossed the Sava, they continued mainly to the northwest, and crossed the Drava only at Pettau (i.e. did not attack the Transdanubia to the north by crossing the Drava at its lower sections, but rather Styria, and crossed the Drava at its upper sections, much before its confluence with the Mura river).

In an important letter sent by Queen Beatrix (King Matthias's widow) in March 1496 (MNL, DL 98454), the queen asked the count of the Máramaros (today Maramureș, North-Romania) chamber about a large transport of salt that has not arrived since 1494

("Quoniam et computa tue administrationis salim camere nostre Maramarosiensis anni 1494. noviter elapsi ex relatione venerabilis Philippi de Brixia rationalis nostri intelleximus te in dicto tempore fecisse incidere tumenos salium ..."). It seems that a rather large amount of salt had not been transported in 1494, and (maybe) remained in the chambers at the Tisza, as – due to lack of waters – they could not deliver the salt ("*de qua quantitate apparet remansisse in cameris prope Ticiam, qui non potuerunt onerari propter defectum aquarum /tumenos?! 20728,*"). Thus, the Tisza river (where the salt transport was carried out in those times) had so low water levels at least for several months (or the entire year) in 1494 that the transportation of large quantity goods, usually carried in large vessels, was not possible. The letter is silent about the character of the period concerning the next year: we cannot be certain whether the water level of the Tisza was still low in 1495 or it was due to other reasons why the chamber administrators did not send the salt afterwards.

Based on all information, and also King Vladislas' Transylvanian itinerary (see e.g. Neumann, 2014), the half-year dry period most probably started at least in mid- or late spring and continued throughout the summer months. Apart from the long-lasting drought, we especially have to emphasise the reported great spatial extent of the events: the low water levels of major rivers can be detected in contemporary documentation not only in the south, south-western parts of the Carpathian Basin, but dry conditions also prevailed in the (north-)eastern parts, and resulted very low water levels of water flows, including the (Upper-)Tisza river. As mentioned by Bonfini, the drought period was followed by hard winter when the Danube was firmly frozen which repeatedly helped Ottoman Turkish military operations in the south.

Apart from Bonfini's general description on the drought that prevailed in Hungary, we do not know how much the drought affected the more northern, north-western areas. Nevertheless, (maybe showing some similarities to the 1507 case), as mentioned in the contemporary town accounts of the royal town of Sopron, torrential rain or cloudburst caused great damages in the vineyards of Sopron in late June (text ed.: Hăzi, 1936).

A possible consequence? Food shortage in SE-Transylvania

Regarding the same year, a rather thought-provoking information on food shortage is also available concerning the East-Transylvanian Secler Sepsiszék area (today in Central-Romania): according to an early September royal charter (ed.: Szabó, 1872), the king allowed the Sepsi Secler delegates to go home earlier from the Diet, and also to send much less armed men (only 1/16) to the royal army, due to the great need and shortage of crops and beverages that prevailed in their homeland in that year ("*Annone et victualium caristia, qua nunc ista vestra patria laborat*"). Knowing that the 1494 drought primarily affected the upper (mountain) catchment area of the Tisza river in (North-)Transylvania, it seems probable that the same drought (combined or not with other natural hazards) could be also responsible for the

very bad harvests and food shortage of some Secler basins, located in the south-eastern part of Transylvania).

It is rather interesting that up to now, apart from the contemporary reference of Marcin Biem (Limanówka, 2001) concerning South-Poland (Cracow area), in the scientific literature no analogous events (or even a dry spell or low water levels) are known (see Malewicz, 1980; Brázdil and Kotyza, 1995; Rohr, 2007; Glaser, 2008) for this year in the neighbouring areas. As for the Czech Lands and Upper-Austria, in fact rather the opposite weather conditions are described: an early May flood was followed by a very unfavourable, wet summer and then by bad harvest; similar information is available for the Salzburg area where both the summer and autumn were very wet (Brázdil and Kotyza, 1995).

1507: GREAT DROUGHT, HAIL, BAD HARVEST AND POVERTY

A contemporary Buda citizen, János Kakas, mentioned in his Almanach that almost in the entire year, and especially in the summer of 1507 there was very great drought in Hungary (source ed.: Kubinyi, 1971), resulting a significant shortage of crops, wine and hay ("*1507. Hoc fere anno et maxime in estate ingens siccitas viguit per Hungariam ubique, ex qua non mediocri penuria frugum, vini et feni provenit.*"). And this is not the only record about the great drought event: a rather extensive set of evidence about this drought, other natural hazards and their consequences were described in the accounts of the bishop of Eger, Ippolito d'Este (source ed.: E. Kovács, 1992).

It is an especially interesting fact that the great drought reportedly affected even such high elevation areas as Eperjes (today Prešov in NE-Slovakia; see Fig. 1) in former Sáros county where leasing and purchase of the tithe was collected after crops: the leasing (*arenda*) and purchase of the tithe were partly paid (on 15 July JC) and partly postponed (to 6 Dec. JC) due to the fact that the great drought in this year destroyed the crops ("*quia siccitas magna isto anno destruxit fruges*"). This last sentence is very important, because here the tax collector gave the great drought ("*siccitas magna*") as 'the' reason for the destruction of cereals. Additionally, the very great drought ("*maxima siccitas*") was also mentioned later, in relation with the Saint Demetrius market in the town of Eger (JC: 26 Oct.; the day when sheeps were traditionally driven back from the open pasture): at that time the cabbages were bought (to be salted), and as there was very great drought, they were (placed) in the meat market (166v. "... *Item in foro Sancti Demetri (október 26.) caules ad salsandum emit pro castro fl. quadraginta uno et d. octuoginta quattuor et hoc fuit propter maximam siccitatem, ideo fuerunt in caro foro.*").

A summer information in the account books is that some time after 4 July a horse, bought in Transylvania, died in the way between Eger and Esztergom due to the heat ("*... et recesserunt 19 iunii ab Agria et quarta iulii expedivi ipsos a Strigonio, cui Aloisio etiam assignavi unum equum ex equatibus Sancti Ioannis, loco quorum*

dimisit unum et veniendo ab Agria ad Strigonium et erat de illis sex emptis in Transilvania mortuus est in via propter calores").

Further interesting information is that in this year there were no fishes in the fisheries (belonging to Eger), and therefore the poor serfs received reduction of the tax (or leasing) ("*Agrie 22 septembris. ... Item ivi extra ad videndum piscaturas, in quibus anno isto non sunt pisces, ... quia pauperes iobagiones non debent agravari in omnibus expensis*"). Moreover, in many cases all over the areas of the bishopric it is also mentioned that there were no bees ("*apes vero non fuerunt*").

In the Heves district in Heves county (and also in Borsod) the harvested crops were bad ("*male fruges sunt omnes*"), and the administrator of the bishopric mentioned that the (bad) price of crops was due to the very bad quality ("*quia male fruges et pessime fuerunt*"). In the same county, in the Debrő (see Fig. 1) district the tax officer similarly reported that although there was some harvested grain, it was worthless ("*quas fruges dederunt capetie ducente tritulate, quia nullius valoris fuerunt*"), and as he also mentioned in detail, market (selling) prices fit the very bad quality of crops ("*et videtur, quod sit vendite octingente et quinquaginta tres cum media et dederunt pretium ut supra et capetias novem et plus modicum pro uno fl. et hoc est, quia pessime fuerunt fruge*"). Similar problems were reported from Borsod county Kaza district ("*quia anno isto hic male fruges fuerunt et vernalia multa intus etc*"), and also in Miskolc district (in the same county) where the bishops' administrator added that he saw the bad selling prices, and grain (harvest) was generally bad there ("*videtur dedisse capetias duodecim pro uno fl. et nota, quod hic generaliter non bene venduntur et fruges etiam male fuerunt*").

In Zemplén county, in the Zemplén district tax was only collected in 1508, and in the Homonna district (today Homonné in E-Slovakia), due to the hail, they could not collect any harvests ("*quia anno isto habuerunt grandines in istis duobus districtibus et non potuerunt collocare in acervis*"). Regarding the tithe of cereals (*frugum*) of the Pásztó district in Heves county (see Fig. 1) almost similar problems were described: the tax officers noted that the cereals were bad in general (i.e. in growth, in quantity/quality), and were destroyed by rains ("*quia fruges male generaliter huc sunt et per pluvias destructe fuerunt*"). Thus, in these cases not the drought, but hail and rains (convective events?) were blamed for the loss of harvest.

In Bereg county the tithe incomes of Szalánk (Shalanky, today in Ukraine) and Bene (see Fig. 1) were rather small and the wine was "light" ("*que vasa sunt valde minora ceteris et vina sunt levia*"), and – as later mentioned – the sold wine was rather bad ("*quia vina sunt villissima*"). Similarly a small quantity was reported in the Razon (Kazon/Kaszony? – today Koson? in Ukraine) district ("*exegit vasa media, que sunt valde minora*") in the same county. The low quantity of wine both in 1507 and 1508 were noted in the bishop's estate in Gyöngyöspüspöki (today part of Gyöngyös town). Concerning the payment of the wine tithe of Pásztó in Heves county (collected on 6 Dec. JC) the inhabitants

asked (and received) a reduction of 10 fl. (they should have paid 75, but paid 65) because the hails destroyed vines and caused lots of other damages ("*quia grandines ibi anno isto destruxerunt vineas et passi sunt multa damna /et ut moris est insimilibus/ relaxavi ipsis fl. decem*"). Similarly, amongst others, the great damages caused by hail was a main reason of tax reduction (on 14 March) in Tolcsva (Zemplén county; in the Tokaj-Hegyalja wine region) from the wine tithes ("*.... Et nota, quod maxima damna passi sunt per grandines anno isto*").

As was also indicated in the further parts of the accounts (talking about the travel to Eger and return to Esztergom), the officer mentioned that "great dearth of things" prevailed ("*112v. Item predicto eundo, stando et inquirendo equos et veniendo domum cum famulis eorum et stabulariis et cum equis exposuerunt a recessu suo ab Agria usque ad adventum ver reversionem eorum fl. quinquaginta novem et certe consideratis omnibus et maxime caristia magna rerum, in via non multum exposuerunt.*"). Possibly the combined effects of natural hazards, followed by bad harvest in basic beverages, resulted the great need.

In Felnémet (see Fig. 1) people received tax reduction in this year due to their great amount of works on the St. John church that had burnt down ("*Residium relaxatum est, quia multum servierunt ecclesie Sancti Iohannis isto anno propter combustionem*"). Described in other parts of the text in more detail, the church of St. John (in Eger) was struck by lightning and burnt down in 1506.

In Tárkány and Cegléd people did not have to pay the tax of St. Michael (JC: 29 Sep.) because of their poverty ("*propter paupertatem*"). This question once more appears later when, apart from poverty, their serving works were also mentioned ("*servitia et paupertatem*"). Great poverty (e.g. in Tárkány: „43v. *Census Sancti Michaelis* (JC: 29 Sep.). *Tharkan debuisse dare fl. quattuor, sed propter nimiam paupertatem sunt eis relaxati.*”) continued also in the next year and provided reasons for further tax reductions in 1508, too. The account also mentions that disease prevailed (p. 319: "*pestilentia*") in the same year. In these cases the reason for tax reduction was mainly the great poverty of people.

An interesting further information was reported in the same account books (4 October, 1507): the wines collected in Besenyő and Keresztúr (today Szirmabesenyő and Sajókeresztúr, located near the Sajó river; see Fig. 1), were partly destroyed, and the remaining part had to be moved to the castle, due to the fact that cellars were filled with water. These circumstances suggest either a (late September–early October) flood (maybe flash flood, torrential rain?) or maybe very high ground water conditions in the area.

As for conclusion, on the one hand a Buda citizen emphasised the great drought that prevailed in Hungary in general, and caused a bad harvest of crops, vine and hay in 1507. On the other hand, from the accounts of the Eger bishopric a broader picture can be obtained: apart from generally low incomes in this year, the great and very great drought was emphasised to be primarily responsible for bad harvests in two cases. Rather interestingly, drought severely

affected the higher elevation areas in the north-northeast (Prešov area, E-Slovakia). Further cases suggest that, apart from the great drought, hail and rainfall caused great damages in the crop harvest as well as in the vine stocks in a number of cases in Central and North-East Hungary. Moreover, in summer the drought was combined with heat (at least) in the central parts of the Carpathian Basin. As a result, an extraordinary bad harvest of crops, hay and sometimes also wine was generally reported not only in the central, north-eastern, low elevation areas of the country, but also in the hilly areas. The low amount and bad quality of crops and wine may suggest that, beyond the significant impact of other natural hazards, (similar to the German areas) already the spring was characterised by a serious water deficit that probably continued (combined with heat and maybe convective precipitation events) in summer and (at least partly) in autumn.

Among other, further consequences a casualty (caused by heat), combustion and, apart from bad harvests of cultivated vegetation, in some areas the lack of fish and in many cases that of bees were reported. As a further cumulative effect (of combined hazards – on an annual or multi-annual level), shortage/lack of beverages and especially poverty prevailed (as well as disease mentioned) in extensive areas, and formed the basis/reasons of tax reduction. There might have been a change in weather around the end of September and/or beginning of October towards a more rainy character that induced flood (and/or high ground water table).

Referred in the Réthly compilation (1962), in his work the contemporary author, Antal Verancsics (1504-1573; source ed.: Bessenyei, 1981) gives the information on the extremely great prices due to the shortage of bread, under the year 1508 ("*mondhatatlan nagy drágaság támadta egész Magyarországbán, kinérnek szik vóta miatt.*"). Very great need in 1508 was also mentioned in the account books of the Eger bishopric, while referring to the expenses of a travel from Eger ("*et certe consideratis omnibus et maxima caristia magna rerum, in via non multum exposuerunt*"). Later in this year a lack of bee-products namely honey and wax (in late March in Eger: "*quia anno non fuit mel neque cera*") was described, and also poverty and pestilence were recorded in the accounts. Apart from this indirect evidence and the potential consequences of the extreme Danube flood in summer 1508 mentioned in Austria (see e.g. Rohr, 2007) that most probably also affected the Danube valley in Hungary, we have at present no more information concerning the character of 1508, and therefore we cannot say in what extent the hazards of the previous year(s) and/or those of 1508 are responsible for the critical conditions prevailed also in 1508 in large parts of Hungary.

As suggested before, in the Czech Lands the summer months of 1506, with special emphasis on June, were mentioned as significantly dry (Brázdil et al., 2013), while in the German areas (according to Glaser, 2008) not only summer 1506, but also spring and autumn of 1507 were notably dry. As for other areas in Europe, apart from the dry spell in Spain (e.g. Dominguez-Castro et al., 2008), in 1506 a significant drought preceded the Lisbon Massacre in Portugal (see e.g. de Gois, 1749). A thought-provoking further information from outside of Europe is that 1506 was the last

year of a severe multi-annual drought, for example, in Central Mexico (Therrell et al., 2004). At present, our only available weather-related information concerning the year of 1506 in Hungary is the above-mentioned lightning and fire of the St. John church in Eger, and a flood – most probably influenced by ice – at the end of the year at Buda that suggest a rather cold (late autumn-)early winter in this year (recorded by the afore-mentioned Buda citizen, János Kakas; see in: Kubinyi, 1971).

DISCUSSION

Drought severity - towards a numerical classification

The magnitude of drought events is usually discussed with using numerical values. In historical climate/hydrology research usually a 3-scaled index classification is applied. This classification is in fact the 'dry part' of the 7-scaled precipitation (monthly) index classification, commonly applied in historical climatology (Brázdil et al., 2013; see also Glaser, 2008; Pfister, 1999 etc.). While in more modern times usually an adequate amount of source evidence is available to classify the intensity of a drought event, the situation is often rather different in the Middle Ages when only one or two short contemporary notes are available on the individual events, and the severity of individual months often cannot be defined.

In our present cases terminology (*siccitas; ingens/magna siccitas; maxima siccitas*), information on the approximate length of the drought as well as severity of consequences (extraordinary low water levels of major rivers for a longer duration, bad harvest due to drought etc.) provide further help in estimating the severity of the individual drought events.

Due to mentioning durations, the picture is relatively clear in case of the 1474, 1479, 1494 and 1507 events: the drought of 1474 is described as annual (or even longer) in duration, the 1507 drought was mentioned as a 'whole year, but especially summer' event, while in case of 1479 a 3-4-month (at least), and for 1494 a 6-month drought was mentioned by the (same) contemporary author. Concerning 1474, 1479 and 1494 extreme low water levels of major rivers and the related historical events (i.e. intensified Turkish attacks – utilising extraordinary low water levels) directly and indirectly also supported the description. As for territorial extension, in 1474, 1479, 1494 and 1507 the authors mentioned "Hungary" and thus, probably in these four cases large parts of the Carpathian Basin had to be affected by long dry periods. Additional information on low water levels of the Drava, Sava and the Tisza rivers, and the large-scale socio-economic consequences also suggest that extensive areas (including the alpine catchments) had to be affected by the long-term water deficit.

Less is known about the 1362 Dalmatian case: although great drought (and need for water) is mentioned, some important socio-economic consequences are known that suggest a significant long-term winter-early spring water deficit, no explicit information in the contemporary documentation is available about the length of

the drought event. This later information, however, would be probably the most clear indicator of a severe drought (see e.g. Pfister et al., 1999). Nevertheless, the rather exceptional nature of socio-economic consequences and legal/administrative decision (as well as some potential Central European parallels) may suggest that this drought event was also extraordinary in magnitude.

Social, political, economic, military and environmental consequences

When talking about the socio-economic effects of droughts, we may group the consequences as follows:

1) Military operations and devastation of extensive areas (including mass loss of lives) supported by hydrological drought (1474, 1479, 1494): the southern defence line of the Hungarian kingdom (and also of Slavonia) against the Ottoman Empire – due to the unfavourable, flat lowland conditions of the borderline areas – was largely dependent on the hydrological defence line formed by major rivers, such as the Drava, Sava and the Danube and their extensive wetland areas. Apart from the winter cases when firm ice cover of major rivers and the lack of notable snow provided good conditions for a rapid 'raid' of Ottoman Turkish troops (e.g. winter of 1474), prolonged low water levels of major rivers (and dry roads) in the summer half year provided equally favourable conditions for intensive military attacks. These military attacks in the last decades of the 15th century affected not only the countries of the Hungarian crown, namely Hungary, Slavonia (and Bosnia), but also the south-eastern parts of Austria (especially Styria). Thus, repeated (and prolonged) great drought events provided more possibilities for military attacks, reported during the dry 1470s and in 1494.

2) Transportation problems during hydrological drought, due to extraordinary low water levels (1494): while low water levels ease the possibilities for crossing, it may cause great problems in river transportation when lacking the sufficient depth of water has the result that deficiencies occur in the supply of even basic beverages such as salt. Thus, although other environmental circumstances, such as great flood (or damages caused by great flood) or shortage of labour could obstruct salt transport along major rivers (e.g. along the Maros river in 1496; see HNA, DL 65441), in the Middle Ages (even if at the moment in only one known case), drought (long-lasting low water levels) could be also a reason for major transportation problems.

3) Drought caused problems for pastoral communities, and – due to lack of sufficient quantity of fodder and drinking water – threatened with a mass instinct of domestic animals: in the drought case of 1362 domestic animals were mentioned to be threatened by prolonged drought. In this case the usual grazing practices and territory of the pastoral community had to be changed temporarily: Morlachs had to leave their territories and (shortly) occupy those of a highly privileged town, to avoid significant loss of animals.

4) Agricultural, socio-economic drought: can be mentioned in relation with the (very) bad harvests, high prices, food shortage and poverty in 1507 (with food shortage and poverty also in 1508). Although drought is a

prevailing factor and may be the main reason for significant socio-economic problems, the drought was combined with other (related) hazards such as heat and convective events (hail, destructive rainfall). Bad harvests, high prices and related uncertainties (even probable casualties) might have been a result of these combined effects (affecting extensive areas). 1507 is the only case when more information is available for a combination of hazards and their consequences. Need and high prices in this year (1507) may be the result of the current bad harvest; however, also with using other Central European parallels, it is that the rather wide-spread poverty was due to the fact that (apart from other social, political circumstances such as generally growing uncertainties due to Turkish attacks in other parts of the country, high taxes etc.) unfavourable conditions prevailed not only in 1507, but also in 1506 (as, for example, in the German and Czech areas), and 1507 would have been already the second year (at least?) with bad harvest results.

5) A further interesting, potential (biological) consequence, also resulting great loss in the cultivated vegetation, might be that around the same time when drought prevailed locusts also arrived (even if the exact consequences on social processes are not reported) and were present (most probably in the 1360s and) in the 1470s. While this invasion caused clearly further socio-economic problems, locusts were 'only' directly reported in Hungary during the drought events of the 1470s (and in the countries where usually locusts arrive from Hungary or Slavonia in the 1360s), while no information is available for their mass appearance in the drought years of 1494 or 1506. However, the outbreak of locust invasions in the 1360s and 1470s clearly coincides with, for example, the prolonged multiannual drought periods occurred in the East European Plain in the early 1360s and 1470s.

One-year shift (or not) with Central-European droughts – any comparison possible?

Although relatively few information is available concerning great medieval droughts, it is interesting that most of the great drought mentions are available concerning the last decades of the 15th century and for 1507. However, due to the low sample size, at present it is yet difficult to draw any conclusion whether or not, compared to other periods, the number of great drought events increased around the turn of the 15th-16th century. The present 'distribution' of known drought evidence is strongly dependent on source availability: as we could see before, most direct mentions of great droughts come from narrative sources, charters and from economic-administrative (institutional) evidence. Prior to the mid-15th century, narratives and accounts (if available) very exceptionally contained weather-related information, and in the charter (and letter) documentation, significant in quantity especially from the early 14th century, any drought-related information appears only in very exceptional cases.

Even if source availability strongly affects our knowledge about medieval droughts, it is still an interesting question why in Hungary (or in Dalmatia) the known great drought years detected are often one year

late in the studied cases compared to the reports of other Central European areas. First of all, we have only a few cases and on this basis no general tendencies can be drawn. It is, however, true that in most of the studied cases, namely in 1362, 1474, 1479 and 1507 important drought events were reported in neighbouring areas for 1361, 1473, 1478 (and/or 1480) and 1506.

It is most probably not the 'fault' of the sources: the referred sources are all domestic, contemporary, clearly dated and although the work of Bonfini has vital importance in 1474, 1479 and 1494, the early 1362 drought was described in a legal document (charter), while the 1494 and 1507 drought cases were mentioned in two-two individual contemporary sources (and also in different source types). We rather suggest that – similar to some of the Czech, Polish and German examples – in some years water deficit might have occurred not only in one, but two (or more) consecutive years, and the drought itself got recorded only concerning the year when the major effects and consequences (i.e. socio-economic) became apparent. This is also possible because, as we could already see in the individual case studies, based on the textual context as well as the severity of consequences, it is possible that dry conditions might have already prevailed in the preceding year(s).

CONCLUSIONS AND OUTLOOK

Although relatively few contemporary sources are yet known that directly refer to droughts occurred in medieval Hungary and Croatia, some of the important events are quite well-discussed in the contemporary written sources. Out of these cases, in the present paper the great droughts reported for 1362 in Dalmatia, and for 1474, 1479, 1494 and 1507 in Hungary and partly Croatia (but also affecting the Eastern Alpine area) are discussed in more detail. It is also an advantage of the available contemporary evidence that the discussed drought events were recorded in various source types, including narratives, economic accounts, private notes, charters and letters – all written by contemporary authors.

It is a common characteristics of these drought cases that they were all rather extraordinary in magnitude, but still were mainly mentioned due to their socio-economic (and political-military) consequences. The long-lasting severe shortage or lack of precipitation resulted extreme low water levels of major rivers accompanied by transportation and border security problems on the one hand, and – combined with other natural hazards – harvest failures, severe food shortage and danger of mass extinction of domestic animals on the other hand. Two (or maybe three) of the mentioned great drought cases were accompanied or /followed by significant locust invasions.

Comparing the discussed drought cases with the drought-related evidence available for Central Europe (Czech Lands, Poland, Austria – and also the German areas), in four cases (i.e. 1362, 1474, 1479, 1507) parallels can be found for the preceding year, than for the year actually mentioned in the Hungarian-Croatian evidence. Due to the fact that droughts are usually known when

consequences were reported, in most cases it is probable that not only the actually mentioned year, but already the previous year was dry.

In the present paper the reported, most extraordinary medieval drought events were discussed in more detail. However, either in the form of direct or indirect reference, more evidence is available on other dry spells, shorter or longer dry periods that will be discussed in a further publication on the subject.

Acknowledgements

The work of the first author was finalised in the framework of the 'Flood Change' ERC research grant. The authors are grateful to György Szabados (Hungarian Medieval Studies Research Group in Szeged, National Academy of Sciences) and Danuta Limanówka (Center for Poland's Climate Monitoring, Warsaw) for their help.

References

- Bal, J., Förster, J., Kauffman, A. (eds.) 1910–1913. Hain Gáspár lőcsei krónikája / Zipserische oder Leutschauerische Chronica. Szepesmegyei Történelmi Társulat, Lőcse [Levoča], 14.
- Bártfai Szabó, L. 1938. Pest megye történetének okleveles emlékei 1002-1599-ig (Charter evidence to the history of Pest county from 1002 to 1599). Magyar Nemzeti Múzeum–Vallási és közoktatásügyi Minisztérium, Budapest, 70.
- Benito, G., Lang, M., Barriendos, M., Llasat, M.C., Francés, F., Ouarda, T., Thorndycraft, V.R., Enzel, Y., Bárdossy, A., Coeur, D., Bobée, B. 2004. Use of Systematic, Palaeoflood and Historical Data for the Improvement of Scientific Methods. *Natural Hazards* 31, 623–643. DOI: 10.1023/B:NHAZ.0000024895.48463.eb
- Bessenyei, J. (ed.). 1981. 1504-1566, memoria rerum: a Magyarországon legutóbbi László király fiának legutóbbi Lajos királynak születése óta esett dolgok emlékezete. Verancsics Évkönyv (1504-1566, memoria rerum: memories of events happened in Hungary since the birth of the last King Lajos, son of the last King László). Magyar Helikon, Budapest, 15.
- Böhm, O. 2011. Hochwassergeschichte des bayerischen Alpenvorlandes: Die Hochwasser der Sommermonate im Kontext der Klimageschichte Mitteleuropas. Dissertation, Universität Augsburg, 317 p.
- Brázdil, R., Kotyza, O. 1995. History of Weather and Climate in the Czech Lands I (Period 1000-1500). Zürcher Geographische Schriften 62. Zürich, 260 p.
- Brázdil, R., Glaser, R., Pfister, C., Dobrovolný, P., Antoine, J.-M., Barriendos, M., Camuffo, D., Deusch, M., Enzi, S., Guidoboni, E., Kotyza, O., Rodrigo, F.S. 1999. Flood Events of Selected European Rivers in the Sixteenth Century. *Climatic Change* 43 (1–2), 239–286. DOI: 10.1007/978-94-015-9259-8_9
- Brázdil, R., Dobrovolný, P., Trnka, M., Kotyza, O., Řezníčková, L., Valášek, H., Zahradníček, P., Štěpánek, P. 2013. Droughts in the Czech Lands, 1090-2012 AD. *Climate of the Past* 9, 1985–2002. DOI: 10.5194/cp-9-1985-2013
- Camuffo, D., Enzi, S. 1991. Invasioni di cavallette e fattori climatici dal medioevo al 1800. *Bollettino Geofisico* 14 (2), 34–39.
- Camuffo, D., Enzi, S. 1994. The climate of Italy from 1675-1715. In: Climatic trends and anomalies in Europe 1675-1715. High resolution spatio-temporal reconstructions from direct meteorological observations and proxy data. Methods and results. Ed. Frenzel, B. Gustav Fischer Verlag, Stuttgart-Jena-New York, 243–254.
- Camuffo, D., Enzi, S. 1996. The analysis of two bi-millennial series: Tiber and Po River floods. In: Jones, P.D., Bradley, R.S., Jouzel, J. (eds.). *Climate Variations and Forcing Mechanisms of the Last 2000 years*. NATO ASI Series 141. Springer, Heidelberg, 47–63.
- Csernus-Molnár, I., Kiss, A., Pócsik, E. 2014. Early instrumental measurements and daily weather observations in Timișoara (Temesvár): 1780-1803. *Journal of Environmental Geography* 7 (1–2), 1–13. DOI: 10.2478/jengeo-2014-0001

- Csukovits, E. (ed.) 2008. Mátyás és a humanizmus (Matthias and the humanism). Osiris Kiadó, Budapest, 117–118.
- de Góis, Damião. 1749. Crónica de Don Manuel. Vol. 2. Lisboa: Off. de Miguel Manescal da Costa, p. 349.
- Długosz, I. 1877–1878. Historiae Polonicae libri XII. In: Opera omnia, Vol. 1., Kraków, 596–597, 603–604, 664–665.
- Domínguez-Castro, F., Santisteban, J.I., Barriendos, M., Mediavilla, R. 2008. Reconstruction of drought episodes for Central Spain from rogation ceremonies recorded at the Toledo Cathedral from 1506 to 1900: A methodological approach. *Global and Planetary Change* 63 (2), 230–242. DOI: 10.1016/j.gloplacha.2008.06.002
- E. Kovács, P. 1992. Estei Hippolit püspök egri számadáskönyvei 1500–1508 (The Eger account books of Ippolit d'Este: 1500–1508). Eger: Heves Megyei Levéltár, 225, 228, 232–233, 235–239, 241, 246, 254, 268, 274, 301, 324.
- Fedeleš, T. 2007. Vallásos áhitat, közöség tudat, reprezentáció. A késő középkori körmenetek főbb jellemzői (Religious devotion, fellowship, representation. The most important characteristics of late medieval religious processions). *Aetas* 22 (3), 59–82.
- Fejér, G. 1834. Codex Diplomaticus Hungariae ecclesiasticae ac civilis. Vol. 9/3. Budae [Budapest]: Typis Typogr. Regiae Universitatis Hungariae, 318, 336–338, 408–411.
- Florianus, M. 1884. Chronica Dubnicense cum codicibus Sambuci Acephalo et Vaticano, cronicisque Vindobonensi picto et Budensi accurate collatum. Historiae hungaricae fontes domestici I/3. Typis M. Taizs, Lipsiae [Leipzig], 3, 198–199.
- Glaser, R. 2008. Klimageschichte Mitteleuropas: 1200 Jahre Wetter, Klima, Katastrophen. Primus Verlag, Darmstadt, 264 p.
- Gunjača, S., Stipišić, J. 1981. Codex Diplomaticus Regni Croatiae, Dalmatiae et Slavoniae / Diplomatički zbornik Kraljevine Hrvatske, Dalmacije i Slavonije. Vol. 17. JAZU, Zagreb, 97–98.
- Gyöngyösi, G. 1988. Vitae Fratrum Eremitarum Ordinis Sancti Pauli Primi Eremitae. Ed. F. L. Hervay. Bibliotheca Scriptorum Medii Recentisque Aevorum. Ser. Nova. Tom. 11. Budapest, 133.
- Házi, J. 1936. Sopron szabad királyi város története. II. rész, 4. kötet, Különféle számadások és adójegyzékek 1454-től 1495-ig (History of the free royal town of Sopron. 2nd part, Vol. 4: Various accounts and taxation protocols from 1454 to 1495). Székely és Társa Könyvnyomdája, Sopron, 357.
- Heim, R.R. 2002. A review of twentieth-century drought indices used in the United States. *Bulletin of the American Meteorological Society* 83, 1149–1165.
- HNA (Hungarian National Archives), Collection of Medieval Documents: DL 65441, DL 98454.
- Hrabak, B. 2010. Naseljavanje hercegovačkih i bosanskih Vlaha u Dalmatinsku Zagoru u XIV, XV i XVI veku (Settling of Bosniak and Hercegovina's Morlachs in Dalmatian Zagora in 14th, 15th and 16th centuries). In: Vlasi u starijoj hrvatskoj historiografiji (Morlachs in older Croatian historiography). Ed. Ivan Mužić: Muzej hrvatskih arheoloških spomenika, Split, 197.
- Kiss, A. 2009. Historical climatology in Hungary: Role of documentary evidence in the study of past climates and hydrometeorological extremes. *Időjárás* 113 (4), 315–339.
- Klaić, V. 1880, 2010 (re-ed.). Vlasi u Hrvatskoj tečajem XIV i XV stoljeća (Morlachs in Croatia during the 14th and 15th Century). In: Vlasi u starijoj hrvatskoj historiografiji (Morlachs in older Croatian historiography), ed. Ivan Mužić, 9–18. Muzej hrvatskih arheoloških spomenika (Museum of Croatian archaeological monuments), Split, 89–112. Originally published in: *Obzor* 181–183, n.p.
- Klimenko, V., Solomina, O. 2010. Climatic Variations in the East European Plain During the Last Millennium: State of the Art. In: Przybylak, R., Majorowicz, J., Brázdil, R., Kejna, M. (eds.). The Polish Climate in the European Context. An Historical Overview. Springer, Dordrecht–Heidelberg–London–New York, 71–102.
- Kubinyi, A. 1971. Budai Kakas János és történeti feljegyzései (The historical notes of János Kakas Budai). *Tamulmányok Budapest múltjából* 18, 59–79.
- Kukuljević Sakcinski, I. (ed.) 1863. Acta croatica/Listibe Hrvatske. Monumenta historica Slavorum meridionalium I. Gaj, Zagreb, 97.
- Kulcsár, M., Kulcsár, P. (eds.) 1976. Antonius de Bonfinis. Rerum ungaricarum decades. Edited by Bibliotheca scriptorum medii recentisque aevorum. Ser.nova 1. Akadémiai Kiadó, Budapest, 4(3), 61; 4(5), 100–101; 5(3), 244–247; 5(4), 254.
- Limanówka, D. 2001. Rekonstrukcja warunków klimatycznych Krakowa w peirwszej połowie XVI wieku. *Mat Badaw, Seria: Meteorologia* 33, Warszawa.
- Ljubić, Š. 1870. Listine o odnošajih između Južnog Slavenstva i mletačke Republike (Documents about relations between the Southern Slavs and Venetian government). Monumenta spectantia historiam Slavorum meridionalium Vol. 2. Na sviet izdala Jugoslavenska akademija znanosti i umjetnosti, Zagreb, 219.
- Lycosthenes, C. 1557. Prodigiorum ac ostentorum chronicon. Henricum Petri, Basileae [Basel], 489.
- Malewicz, H.M. 1980. Zjawiska przyrodnicze w relacjach dziejopisarzy polskiego średniowiecza. Monografie z Dziejów Nauki i Techniki, Vol. 123. Ossolineum, Warsaw, 83 p.
- Pertz, G.H. 1851. Monumenta Germaniae Historica. Scriptorum. Vol. 9. Hannoverae: Impensis Bibliopolii Aulie Hahniani. Continuatio Mellicensis, 522.
- Neumann, T. 2014. II. Ulászló király délvidéki utazásai: 1494–1496 (Travels of king Vladislaus II in South-Hungary: 1494–1496). *Bácsország* 68, 49–56.
- Pálfa, I. 2004. Belvizek és aszályok Magyarországon. Hidrológiai tanulmányok (Inland excess waters and droughts in Hungary. Hydrological studies). Közlekedési dokumentációs Kft., Budapest, 492 p.
- Pálfa, I. 2009. Aszályos évek a Kárpát-medencében a 18–20. században (Arid years in the Carpathian Basin 18th–20th century). *Klíma-21 Füzetek* 57, 107–112.
- Pfister, C., Brázdil, R., Glaser, R., Barriendos, M., Camuffo, D., Deutsch, M., Dobrovolný, P., Enzi, S., Guidoboni, E., Kotyza, O., Miltzer, S., Rácz, L., Rodrigo, F.S. 1999. Documentary Evidence on Climate in Sixteenth-Century Europe. *Climatic Change* 43 (1–2), 55–110. DOI: 10.1007/978-94-015-9259-8_3
- Pfister, C., Weingartner, R., Luterbacher, J. 2006. Hydrological winter droughts over the last 450 years in the Upper Rhine basin: a methodological approach. *Hydrological Science Journal* 51, 966–985. DOI: 10.1623/hysj.51.5.966
- Rohr, C. 2007. Extreme Naturereignisse im Ostalpenraum. Naturerfahrung im Stätmittelalter und am Beginn der Neuzeit. Köln–Weimar–Wien: Böhlau Verlag, 441–445.
- Schmauk, M. 1889. Supplementum analectorum terrae Scepusiensis. Pars II. Szepesváraljae, 48.
- Smičiklas, T. 1914. Codex Diplomaticus Regni Croatiae, Dalmatiae et Slavoniae / Diplomatički zbornik Kraljevine Hrvatske, Dalmacije i Slavonije. Vol. 12. Jugoslavenska akademija znanosti i umjetnosti, Zagreb, 437.
- Smičiklas, T., Kostrenčić, M., Laszowski, E. 1915. Codex Diplomaticus Regni Croatiae, Dalmatiae et Slavoniae / Diplomatički zbornik Kraljevine Hrvatske, Dalmacije i Slavonije. Vol. 13. Tisak Dioničke Tiskare, Zagreb, 210–212.
- Stipišić, J., Šamšalović, M. 1916. Codex Diplomaticus Regni Croatiae, Dalmatiae et Slavoniae / Diplomatički zbornik Kraljevine Hrvatske, Dalmacije i Slavonije. Vol. 16. JAZU, Zagreb, 412–413.
- Szabó, K. 1872. Székely oklevéltár (Secler chartulary). Vol. 1: 1211–1519. Magyar Történelmi Társulat, Kolozsvár [Cluj Napoca], 281–282.
- Szabó, A.P. 2014. Caspar Hain löcsei krónikája. Egy kompiláció forrásai (The Löcse Chronicle of Caspar Hain. Sources of a compilation). In: Clio inter arma: Tanulmányok a 16–18. századi magyarországi történetírásról (Clio inter arma: Studies on the history writing in the 16th–18th-century Hungary). Ed. Tóth, G. MTA BTK Történettudományi Intézet, Budapest, 169–202.
- Telelis, I. 2008. Climatic Fluctuations in the Eastern Mediterranean and the Middle East AD 300–1500. *Jahrbuch der Österreichischen Byzantinistik* 58, 167–207. DOI: 10.1553/joeb58s167
- Therrell, M., Stahle, D.W., Soto, R.A. 2004. Aztec drought and the "course of one rabbit". *Bulletin of the American Meteorological Society* 85, 1263–1272. DOI: 10.1175/BAMS-85-9-1263
- Vermes, L., Pálfa, I. 2007. Aszályok az újkori történelemben: Magyarország és Európa (Droughts in the modern history: Hungary and Europe). *Historia* 29 (5–6), 53–55.
- Wetter, O., Pfister, C., Werner, J.P., Zorita, E., Wagner, S., Seneviratne, S.I., Herget, J., Grünwald, U., Luterbacher, J., Alcoforado, M.-J., Barriendos, M., Bieber, U., Brázdil, R., Burmeister, K.H., Camenisch, C., Contino, A., Dobrovolný, P., Glaser, R., Himmelsbach, I., Kiss, A., Kotyza, O., Labbé, T., Limanówka, D., Litzemberger, L., Nordl, Ø., Pribyl, K., Retsö, D., Riemann, D., Rohr, C., Siegfried, W., Söderberg, J., Spring, J.-L. 2014. The year of unprecedented heat and drought of 1540 - a worst case. *Climatic Change* 125, 349–363. DOI: 10.1007/s10584-014-1184-2