



The great (1506–)1507 drought and its consequences in Hungary in a (Central) European context

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Abstract

Although in contemporary documentation 1506–1507 is the best-documented drought event in the medieval and sixteenth- and seventeenth-century Carpathian Basin, until now no investigations have been carried out on this subject. Based on contemporary sources—such as narratives, charters, official and private correspondence, estate, town, county and taxation accounts—a concise overview of the documented natural–physical characteristics, temporal–spatial distribution of the drought event and related weather extremes is provided. In a European context, the present investigation reveals that 1506 was a dry year not only in the Carpathian Basin but also in most of Europe. Drought continued in the Carpathian Basin and Italy in 1507, while opposing weather patterns developed in West–Central, Western and Northern Europe, showing similarities to the 2007 and 2015 summer heat and drought events. In the Carpathian Basin, the drought was characterized by the critical low water levels of the River Tisza, heat and high-intensity convective events. Major socio-economic consequences were the higher occurrence rate of major urban fires, bad harvests (cereals, grapevine/wine, hay) and livestock problems (lack or loss of bee, bee products, sheep, cattle, fish, fur)—the latter ones might serve as indicators for future studies. The drought induced numerous individual and institutional responses, including various types of tax relief and common works. The ensuing plague epidemic reached a particularly high level in Hungary; the drought, bad harvests, a change to cooler and wetter conditions, and nutrition problems could have contributed to the intensification of the epidemic outbreak in 1508–1511.

Keywords Medieval Hungary · Drought · Harvest failure · Livestock · Administrative response · Epidemics

Introduction

Drought is one of the most important natural hazards worldwide, and has particular importance in the Carpathian Basin. Due to its wet continental climate, most areas of historical Hungary and Slavonia were prone to droughts, even if the entire Basin was rarely affected at once. The eastern, north-eastern and southern parts of the Basin, especially the Great Hungarian Plain and

Transylvania, were severely affected by, sometimes multiannual, extensive droughts (see, e.g. Érkövy 1863; Boa 2012).

While discussing droughts presented in historical documentation, we have to differentiate between the most relevant drought types. Whereas meteorological drought means direct reports on the lack of precipitation, hydrological drought is related to low water levels in rivers, lakes, wetlands or groundwater (latter subtype, groundwater drought) that occurs when meteorological drought has already been present for a while. Agricultural drought reflects the conditions when a lack of precipitation and low groundwater levels obstruct vegetation in its development, with usually poor (crop, hay) harvest results. Finally, we speak about socio-economic drought when the negative consequences of the abovementioned drought types become apparent and cause significant problems to society, such as shortage of drinking water, high prices, food shortage, dearth and famine. These problems induce notable administrative responses initiated for crisis management, to buffer the negative impacts of drought, and to prevent similar future scenarios (see, e.g. Brázdil et al. 2018).

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The analysis of historical droughts is currently one of the most important topics of discussion in historical climatology and hydrology; European and global overviews have recently been published (see, e.g. Brázdil et al. 2018, 2019). As for historical Hungary and Slavonia, the available documentary evidence on medieval droughts has been recently presented by Kiss (2017, 2019a) and Kiss and Nikolić (2015), while socio-economic impacts of selected early modern drought events, such as the great droughts of 1717–1718 and 1863, have been studied on a local–regional level by Csáki (2010) and Boa (2012). Discussing long-term characteristics, the most relevant droughts of the last centuries in Hungary have been listed briefly by a number of authors (e.g. Reizner 1899; Érkövy 1863; Rác 1999; Pálfai 2009; overview: Kiss 2009).

The (1506–)1507 drought event is probably the best-documented among the medieval and most of the early modern droughts in the Carpathian Basin. This severe drought, however, occurred in the middle of the late fifteenth to early sixteenth century wet anomaly, as indicated by the multi-decadal stalagmite and sedimentary-based medium- or low-resolution hydroclimate reconstructions (overview: Kiss 2019a). Despite the rich documentation, until recently, this drought was unknown to historians and natural scientists.

Although not all aspects of the 1506–1507 drought were discussed in contemporary documentary evidence, in large parts of medieval Hungary, a relatively detailed overview can be presented based on the reported extreme events and their documented socio-economic consequences. Consequently, in the present paper, three major topics are addressed: (1) drought, weather, weather-related extremes and the (potential) spatial and temporal extension of the drought in 1506–1507 (meteorological, hydrological drought); (2) economic consequences, including bad harvests, loss of livestock and the consequent plague epidemic (agricultural and socio-economic drought); (3) detectable socio-economic impacts and societal responses, dearth, poverty and the administrative intervention.

Study area, sources

The investigated area comprises medieval Hungary, covering present-day Hungary, Slovakia, Eastern Austria, South-Western Ukraine, Western and Central Romania, Northern Serbia, Northern Croatia and Eastern Slovenia. Due to the unusually high density of evidence, the north-eastern part of medieval Hungary is studied in more detail. The most important, applied source types are contemporary tax and income accounts (Eger), narratives, legal documentation (charters) and official and private correspondence.

Invaluable reports are available in two contemporary narratives, but especially in the annalistic notes of a Buda citizen, János Kakas, born in 1483 (critical edition: Kubinyi 1971).

Between 1504 and 1506, he studied in Cracow; on 4 February 1507, he returned to Hungary. From March 1507, as a school rector, Kakas spent most of his time in Eger, where the key source of our investigations, the bishop's accounts, was compiled. Another important narrative is the chronicle of Antal Verancsics/Antun Vrančić: while discussing the historical events of his lifetime (1504–1566), he noted the “unspeakable” high price of bread all over the country in 1508 (critical edition: Bessenyei 1981). A third, more uncertain narrative of this period is the Transylvanian chronicle of Matthias Miles, published in 1670 (Miles 1670), which contains non-contemporary information on a great drought and hard winter in the year of the birth of King Louis (Lajos), dating these events to 1503. Nevertheless, as Louis was born in 1506, it is possible that the memory of either a great 1503 or 1506 drought, or both, were preserved in this seventeenth-century source.

Even if no direct reference to drought is available in contemporary legal documentation, the charters related to tax relief and especially the higher number and significance of controversies over hay may provide interesting parallels to the issues related to crop and hay harvest. Contemporary official and private correspondence, namely royal and tax collectors' letters, also contain useful information, referring to need and poverty at a community, regional or country level (Kiss 2020).

Economic sources, especially accounts, provide the most valuable information in the studied years: numerous accounts on incomes and/or expenses are available on an individual, municipal or diocese level in the country. However, only a few of them contain data directly or indirectly connected to the drought and its potential socio-economic consequences. The most important accounts, compiled between 1500 and 1508 (critical edition: E. Kovács 1992) by the administrator(s) of Ippolit d'Este, the bishop of Eger, who lived in Ferrara (Italy) at that time. To maximize his income, he sent his own administrators from Italy who, knowing their lord's desperate need for money, took great care in providing the causes, at local and/or regional level, of a drop in revenues. Hence, the accounts of the bishop of Eger are—compared with other contemporary tax or any other types of accounts—so exceptionally detailed in describing, among others, drought, heat, ice, hail, rain, flooding, bad harvests, poverty, loss of livestock or even charity expenses. Tithes and other incomes, expense and purchase reports are available for a more or less systematic overview only in some years (i.e. 1501, 1503 and 1507), while occasional reports and accounts are added, here and there, regarding the years in between.

Although market prices of agricultural and other goods are sometimes described in accounts, for the study period, only sporadic information can be gathered, which does not reflect the full picture on price trends and levels; in Hungary, price series became more continuous mainly after the mid-sixteenth century (Kazimir 1976; Dányi and Zimányi 1989; Simon 2018). One, almost complete, price list is known from the

early sixteenth century and is also applied in this study: the wine production and selling prices of the vineyards in Tállya in the Tokaj-Hegyalja wine region, owned by Bardejov (historical Bártfa/Bartfeld) town, covering the years 1498–1548 (Gecsényi 1966; Fügedi 1972).

Methodology

In the present study, contemporary sources, with a cross-comparison of the different source types, are utilized; metadata of each evidence were carefully collected and interpreted, applying the method of critical source evaluation. The only non-contemporary source (Miles 1670) is referred to separately from contemporary sources. Beyond the direct references on drought, a high number of indirect evidence was incorporated in the analysis.

The original, Julian calendar dates are provided in the Supplementary (Suppl. Tables 1, 2), while Gregorian calendar

dates were applied throughout the paper; for 1506–1507, this means a ten-day difference compared with the Julian calendar dates of the contemporary documentation. Apart from the documentary-based information available for these years in Europe in scientific studies, the tree-ring-based annual-resolution hydroclimate reconstruction of summer precipitation and spring–summer soil moisture conditions of the Old World Drought Atlas (Cook et al. 2015; hereafter OWDA; Suppl. Fig. 1) is also considered in short-term comparisons.

Results

The weather of 1506–1508 in a European context

In Central Europe, the wet-cool year of 1505 was followed by a mild winter and spring in 1506, May and June were cool in the Czech Lands, but the summer was generally hot and very dry with destructive convective events in Western and Central

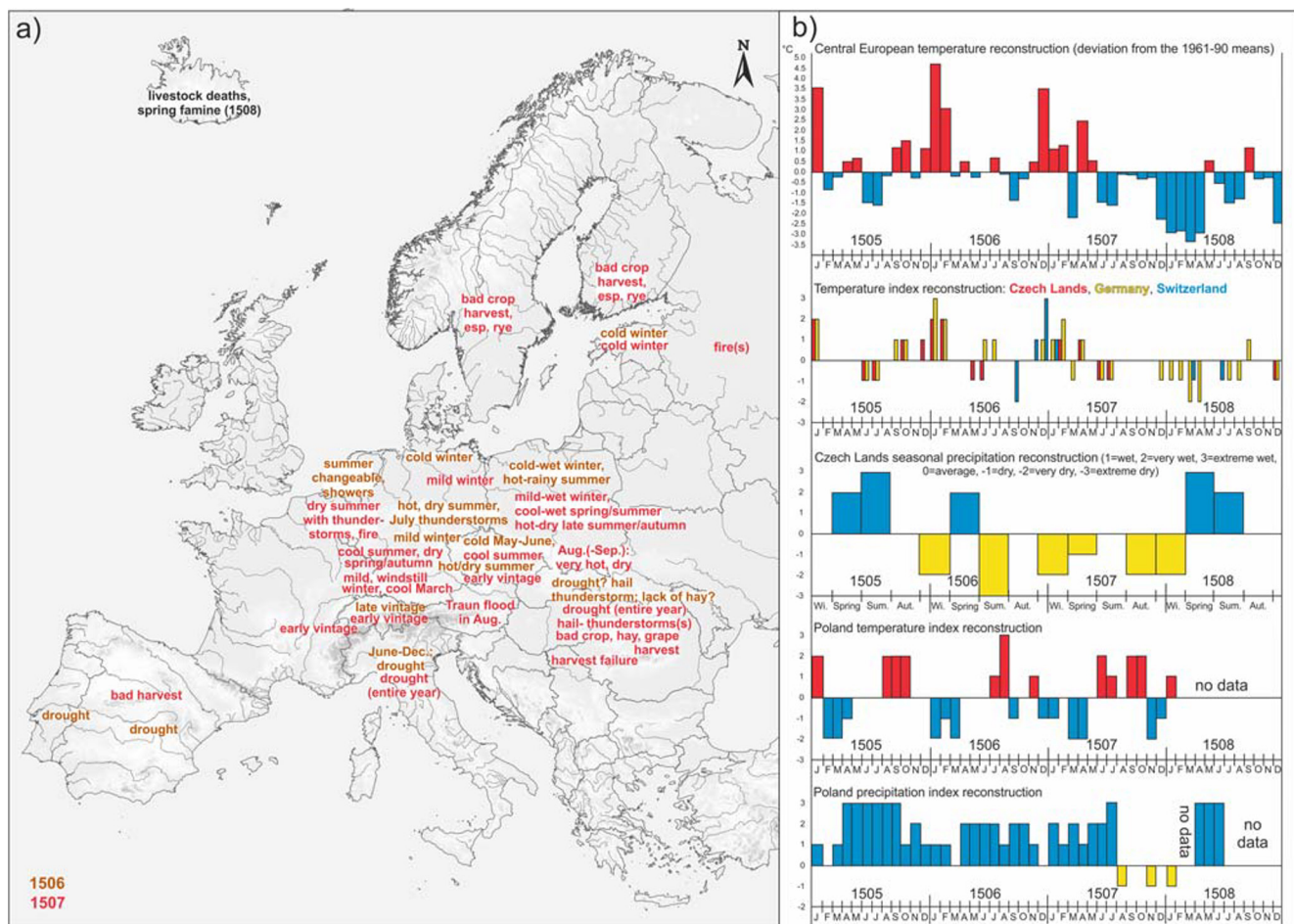


Fig. 1 **a** Weather-related information from 1506 to 1507 in Europe (brown colour means 1506, red is 1507; data: Buisman 1998; Limanówka 2001; Brázdil et al. 2013a, b; Kamen 2014; Kiss and Nikolić 2015; Euroclimhist: Pfister 2015; Savignac 2016; Kiss 2017; Kiss et al. 2017; Retsö 2017; Ogilvie 2019). **b** The Central European

temperature reconstruction, the temperature index reconstructions of the Czech Lands, Germany and Switzerland, the precipitation index reconstruction of the Czech Lands and the temperature and precipitation index reconstructions of Poland for 1505–1508 (Dobrovolný et al. 2010, 2015; Kilar 2010; Brázdil et al. 2013a, b)

Europe, followed by very cold September in Switzerland. Drought prevailed in Southern Europe; in Italy, a perennial drought started from June 1506. In Poland (and the Baltic), the cold and snowy winter and March of 1506 were followed by a wet year and hot but precipitation-rich summer (Fig. 1a, b).

In Hungary, in the town accounts of Bratislava (historical Pozsony/Pressburg) on 30 January, a note was initiated as the town paid to boatmen for protecting the ships when the Danube ice had passed, which means that a considerable amount of ice developed on the river, and also that a prolonged mild period started in mid-/late January. In April, another payment note referred to the woods collected during the ice (jam?) flood, altogether suggesting until mid-January was not mild (AMB K60/83, 122). As reported by Kakas and the episcopal accounts, on 3 August, the cathedral of Eger was struck by lightning and largely burnt down. Furthermore, Kakas mentioned rains with strong winds, in the days around 22 October (Suppl. Table 1). Marked under the 1506 expenses, on 21 December, the very great ice on the Danube in Buda was mentioned in the episcopal accounts, and an early-May 1507 note in the Bratislava accounts suggests that the ice was thick enough some time during the winter to prepare the road over the Danube ice (AMB K61/146). The monthly temperature reconstruction of Central Europe marks December as unusually mild, which seems at odds with the great ice on the Danube in Hungary. However, the reconstruction for Poland indicates a cold December, and a frosty period with snow was also reported in the Czech Lands at the beginning of 1507 (Fig. 1b; Brázdil et al. 2013b).

Winter and spring 1507 were generally mild and dry with a cold March(–April) in Poland and Germany and considerable mid-spring frost in the Czech Lands, while summer was cool (and dry) in the German and Czech areas—and probably also in Scandinavia, while the summer was hot and dry in the Netherlands (with thunderstorms) and Poland. The early vintage in Burgundy and Switzerland may also reflect on warm spring–early summer conditions. The perennial drought continued in Italy throughout the autumn, which was also mainly dry (and warm) in the German and Polish territories (Fig. 1a, b).

Under the year 1507, János Kakas described a very great summer drought (“*ingens siccitas*”), adding that the drought prevailed the whole year. This drought was directly mentioned in two cases in the episcopal accounts. First, as the single cause of harvest failure, on 25 July 1507 in the north-east, in Prešov (historical Eperjes/Eperies) in Sáros County, and then the very great drought, as the only reason for the high cabbage prices, was recorded in Eger on 5 November. Furthermore, on 3 August, the great heat was noted in the episcopal accounts, as a horse died in this heat on the road between Eger and Esztergom (Suppl. Table 1; Fig. 2).

Extensive hailstorms were also reported in 1507. The destruction caused by the hail was mentioned in the episcopal accounts in March, regarding Tolcsva and Szántó—

presumably reflecting on a hailstorm that occurred in 1506—and in June a rather extensive area in the Humenné and Zemplín (historical Homonna, Zemplén) districts (today NE Hungary, E Slovakia) was hit by devastating hailstorms. Referred to in late November 1507, perhaps around the same time, the Pásztó area (North Great Hungarian Plain) was also severely affected, where damaging rains were additionally mentioned as a reason for tax relief (Suppl. Table 1; Fig. 2).

In detecting temperature conditions of the late spring–summer period, phenophase information may provide useful evidence. Although no vine harvest dates are known from 1506 or 1507, the dates of the beginning of the first, second and third works in the vineyards in Tállya and Szántó (Tokaj-Hegyalja wine region), owned by Bardejov, are available for the period 1498–1548 (Gecsényi 1966; Suppl. Fig. 2). In 1506, 1507 and 1508, the first works started on 12 March, 4 March and 9 March, respectively. While all three dates are relatively early, compared with the rest of the period, the vineyard opening works of 1507 is one of the earliest dates of the studied 50 years, suggesting that—in accordance with the Central European temperature reconstruction for 1507—February was considerably milder than usual. Despite the even higher reconstructed Central European temperatures, the opening works started more than a week later in 1506 than in 1507 (Dobrovolný et al. 2010; Fig. 1b). In 1506 and 1507, the tendency is the same in Tállya and Szántó regarding the second and third works; especially in 1507 when the two dates, probably reflecting warm April–May conditions, are among the earliest in the 50-year period. In comparison, in the famous drought year of 1540 (European overview: Wetter et al. 2014) the first works were late (9 April) in Tállya and Szántó, but because of the hot spring and early summer, the third works started even earlier than in 1507 (Suppl. Fig. 2).

In 1506–1508, floods were reported in four cases. In early 1506, there was an ice (jam) flood on the Danube at Bratislava (AMB K60/83), and around or after 25 December 1506, the Danube flooded at Buda. Since on 21 December the great ice of the Danube is mentioned at the same place, there is a chance that the flood was related to ice jamming. Possibly a flash flood was recorded on 14 October 1507, while a very great double flood wave occurred on the Danube in Austria in August 1508 (Rohr 2007), indirectly also detectable in the Bratislava town accounts (Suppl. Table 1; Kiss and Laszlovszky 2013). Thus, the three reported flood events in 1506 and 1507 were flood types more related to high (convective event) or low (ice jamming) temperatures than to precipitation conditions.

Based on the OWDA, in the (spring–)summer period of 1506, a spatially extensive drought is detectable in the Carpathian Basin and in Central, Western and Southern Europe. However, the OWDA suggests summer 1507 as equally dry in Hungary and Slavonia. Considering the

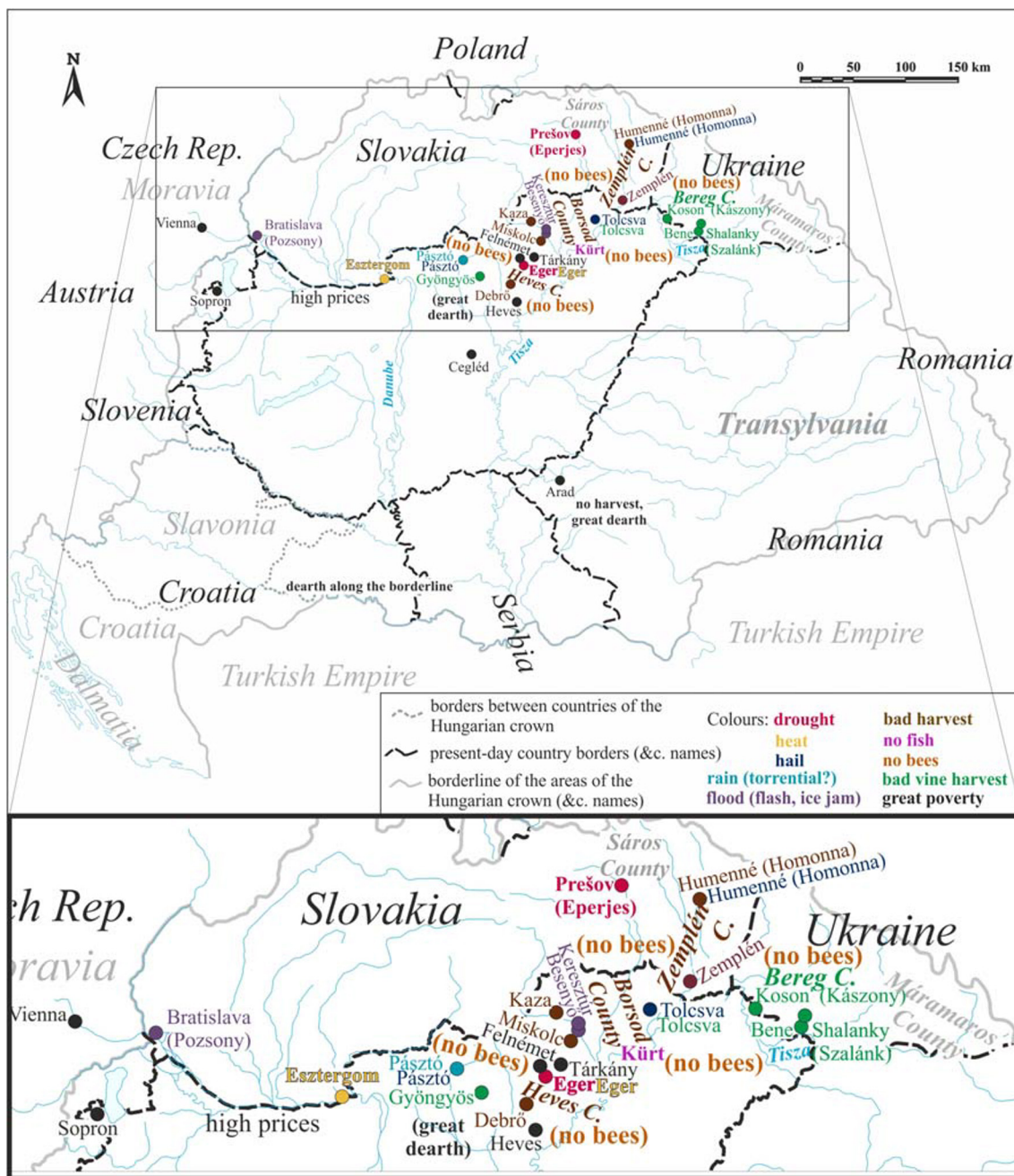


Fig. 2 Weather extremes and their reported socio-economic consequences in 1506–1507 (based on the present study; colour codes are provided in the legend)

fluctuations of the (spring–)summer hydroclimate between 1450 and 1550, 1506 and 1507 do not appear as outstanding drought extremes (Suppl. Fig. 1).

Thus, in documentary evidence, most weather extremes were recorded in 1507, and only a few direct reports are known from 1506, while tree-ring evidence suggests drought for both in 1506 and 1507, especially in the southern, central, north-eastern and eastern parts of the Carpathian Basin. No drought report is available from 1508, and based on Central European evidence (Rohr 2007; Kilar 2010; Brázdil et al.

2013a, b; Glaser 2013) and the OWDA the (spring–)summer 1508 was already cooler and wetter.

In 1507, and probably also in 1506, the drought, even in summertime, did not necessarily equate to a complete lack of precipitation. Nonetheless, precipitation fell in the form of “bad rains”: highly destructive convective events such as hailstorms, thunderstorms and heavy showers that altogether damaged the harvest, eroded the soil and plants, or ran off the hardened soil before penetrating deep enough to moisten it or reach the plant roots, causing groundwater drought.

Socio-economic consequences of the drought and (related) weather extremes

Most of the information about the great drought is available through its impact on agriculture and the built-up environment. In this section, these documented impacts are discussed in more detail.

Heat, convective events and the built-up environment: unintentional fires

Prolonged periods of dry weather, especially combined with heat and the higher frequency of thunderstorms, are often associated with an increase in the occurrence of fires. Struck by lightning, the Saint John Cathedral in Eger largely burnt down on 3 August 1506; the event was reported by the episcopal accounts and also by János Kakas. Repair works after the fire were mentioned in this and the following year, and the renovations continued afterwards (Kubinyi 1971; Suppl. Table 1; Domokos 2015).

According to Kakas, on 24 April 1507, an entire village near Eger (Almegyer) burnt down, while on the next day the market town of Cegléd in the northern part of the Danube–Tisza Interfluve shared the same fate (Kubinyi 1971). Without mentioning the exact date and reasons, the fire destruction of the monastery in Sárospatak was also recorded in December 1508 in the episcopal accounts: the fire occurred in 1508 or shortly before (Suppl. Table 1). Fire data alone in itself does not provide any information on temperature or precipitation conditions; however, based on Central European parallels (Fig. 1b), a considerably warmer than average April after a cool March might have enhanced the chances for the occurrence of village/urban fires.

The impacts of drought and related weather extremes on agriculture

Bad cereal and hay harvest A rather frequently mentioned problem was the (very) bad cereal harvest in 1507 that was responsible for the high prices in 1507 and, at least partly, for the extreme high prices of bread “in Hungary” also in 1508, even if in the latter case the effects of the approaching pestilence might have had negative effects on price conditions, too. Kakas blamed the drought for the great shortage of cereals, wine and hay in 1507 (Kubinyi 1971; Bessenyei 1981; Suppl. Table 1). In the north-eastern part of the country, sometimes not only settlements, but entire regions were reportedly hit by the very bad cereal (usually mainly wheat, partly barley, rye and oat) harvest, with “burnt” seeds. Particularly bad cereal harvests were described in summer 1507 in the Humenné and Zemplín districts (Fig. 2); the harvest was so damaged that people could not even collect the spikes into sheaves—a typical sign of a serious agricultural drought. The situation was similarly

difficult in the mountains of the far north-east, in Prešov and Bardejov in July. As presented before, not only drought but also destructive convective events caused great damage.

Reflecting on general, low-quantity and low-quality harvest conditions, lower tithe incomes and “bad” market prices were reported in numerous locations in Heves, Borsod, Sáros and Zemplén Counties in the north-central and north-eastern parts of the country (Fig. 2). In Kaza (Borsod County), summarizing cereal tithes, the administrator added that most of the harvest was from the spring sowings, which is generally valued less than winter crops. Spring sowings often appeared in larger quantity when unfavourable weather conditions in autumn and/or winter/early spring forced people to reutilize lands for spring sowings (Suppl. Table 1). The “unfavourable” conditions usually meant drought and/or deep frosts in winter or (early) spring—these two factors, particularly in combination, were especially harmful for winter sowings. Winter was mostly mild in 1507, but the December and early January were presumably cold; the perennial drought, mentioned by Kakas, also negatively influenced the hopes for the winter crop harvest.

Consequently, in the areas that belonged to the Eger diocese in taxation, especially the north-eastern, hilly regions—the present-day North-East Hungary, East Slovakia and South-West Ukraine—were reportedly hit by the very bad harvests. Applying the pattern of droughts of the late 1710s, the early 1790s and in 1863, when the north-eastern parts of the country were hit by drought, the Great Hungarian Plain and Transylvania were usually also in drought (e.g. Kiss 2009; Csáki 2010; Boa 2012). This is in accordance with the OWDA hydroclimate reconstruction for 1506 and 1507: the central, southern and eastern parts of the Carpathian Basin were in drought in both years.

Regarding West Hungary, in the tithe accounts of the Veszprém chapter, with an extensive tax-paying region north of Lake Balaton in the Transdanubia, no sign of a weaker harvest is detectable in 1506 or 1507 (critical edition: Madarász 1997). The same is true for the available accounts of Sopron and Bratislava towns (Házi 1928; HNA DF 277117–277119). Based on the OWDA, the western, north-western parts of the Carpathian Basin were affected less by the drought. With much higher annual precipitation sums (over 600 mm; up to 800–900 mm), compared with the Great Hungarian Plain (mainly under 500 mm) and the Transylvanian Basins (under 600 mm), the impact of a moderate drought has no negative effects on the crop yields.

Grapevine harvests, wine quantity and quality The conclusions of János Kakas regarding the shortage of wine in the country in 1507 are supported by the episcopal accounts. In the lowland areas of Bereg County, the too few and “light” wines for the 1507 tithe were mentioned in two villages. It was reportedly the consequence of devastating hailstorms;

generally, the greatest problem noted in taxation was the rather low quantity of wine in this year (e.g. Koson'/Kászony, Gyöngyöspüspöki, Tolcsva). Gyöngyöspüspöki and Tolcsva, the infamous wine-producing areas of the Eger bishopric, were badly hit already in 1506, as the great damage, caused by hail, was first noted on 14 March 1507 in the tithe accounts. Problems continued in 1507 and particularly in 1508: the high price of wine in Gyöngyöspüspöki was mentioned in the episcopal accounts in October 1508, while low-quality wine was purchased in late October 1508. The little quantity of harvested grapevine, again due to hail, was also noted when Pásztó had to pay the wine tithe in December 1508 (Fig. 2; Suppl. Table 1).

The wine production prices in 1498–1548 in the vineyards of Bardejov show a more significant increase in the cool and wet year of 1505, and then between 1506 and 1508 (Suppl. Fig. 3). The difference between a very good and considerably weaker harvest year might explain these changes (Suppl. Fig. 4), even if the regions producing wine in large quantities usually had multiannual reserves that significantly buffered the negative impacts of two bad harvest years and, therefore, one bad year did not necessarily cause notable changes in selling prices (Fügedi 1972).

Mainly caused by the lower quantity of produced wine, in both the north-eastern (Tállya) and western (Sopron) parts of Hungary, the higher wine prices of 1505–1509, but especially of 1508, meant a considerable 1.5–2-fold increase compared with 1499–1504. Nevertheless, this increase cannot compete with the great price spikes of 1519–1520 and 1524–1525, which latter jumps were strongly (but not only) induced by the devaluation of the denar. In 1520, for example, there was a complete harvest failure in Tállya; the situation was problematic, but clearly not so bad in 1506–1508 as in 1520 (Dányi and Zimányi 1989; Kiss 2020; Suppl. Figs. 3, 4).

Shortage of cabbage and hay in 1507 Very high price of cabbage, bought for winter preservation, was mentioned in late October, during the country market in Eger: severe drought was blamed for the bad harvest results (Suppl. Table 1). As cabbage develops best in a wet environment, it is particularly sensitive to drought, and based on the Central European evidence, also the autumn was dry (Fig. 1a, b). Preserved cabbage was the basic vitamin source in wintertime; thus, the very high price of cabbage meant that most of the population probably did not have access to an appropriate vitamin source the next, cold and long winter (see Fig. 1b).

Beyond János Kakas' reference on the significant shortage of hay in 1507, further evidence is available in the Eger episcopal accounts (Suppl. Table 1). On 9 October 1507, the census of Felnémet and Maklár was fully released for the work of inhabitants in hay mowing, suggesting that in some areas there were quite enough mowing works, and thus the harvest was not necessarily bad everywhere. A shortage of hay is likely also reflected in the increased number of hay-related legal trials: it

is somewhat thought-provoking that the number of charters recording problems of illegal use or mowing of hay multiplied in 1506 and 1507 (e.g. HNA DL 63522, 68663, 48934, 36399, 94309–94310, 84051, 21794, 37815). Some charters, even in 1509 or 1510, refer back to hay-related legal cases that occurred three years before (e.g. HNA DL 37860, 37864).

Potential drought-related impacts on animal husbandry

In 1506 and 1507, mass loss of livestock can be deduced from contemporary sources. On the one hand, these problems—at least partly—were the consequence of the shortage of hay, caused by the drought. On the other hand, further weather-related circumstances, among other problems, might have also contributed to the high death and/or low reproduction rates of livestock.

Great loss of lambs in the north-east—cattle and horse export prohibited in the east

On 12 February 1507, the administrator of the Eger bishopric reported on significant problems causing a lower income of lamb tithe in Sáros County, in the north-eastern regions of the Carpathians. Due to great losses of animals, the payment of the 1506 lamb tithe in Szabolcs County, mainly located in the lowland areas of the Great Hungarian Plain, was postponed to early 1507. No information is available in the bishop's tax accounts concerning the reason for the mass loss of young sheep: a disease, weather extremes, too much wetness or drought, the shortage of fodder (and water), too cold or hot weather could also be contributing factors. Although the winter was generally mild in Central Europe in both 1506 and 1507, as discussed before, in Hungary there were prolonged frosty periods in both years. Moreover, the winter of 1506 was cold and snowy in Poland (Fig. 1b), and therefore it is possible that at least in the north-eastern part of the Carpathian Basin, located in the neighbourhood of (Little) Poland, the winter–early spring was also colder.

In Hungary, the most usual time for the birth of lambs, in traditional animal husbandry, is winter or early spring. Mass loss of lambs most often occurs when the ewe is underfed (i.e. lack of fodder) during their five-month gestation, the fodder is cold or frozen, or lacking the necessary vitamins. In these cases, the newborn lambs, if born alive, are much more sensitive to infectious diseases and they die in large numbers (Úr 2009). A long winter and cold early spring may also have negative effects, as in these cases often fodder shortage develops, and the ewe cannot feed the lamb properly.

Furthermore, in 1507, the Duke of Transylvania prohibited the export of cattle and horses to the Turkish Empire (Simon 2006). As in those years there was peace with the Empire, it is rather probable that—similarly to the years 1495, 1499 and 1525—the prohibition was the consequence of shortage of livestock caused by the (countrywide) lack of fodder, mentioned by Kakas.

Lack of bees, honey and wax: an indicator of drought severity and/or other problems? In the Eger episcopal accounts, rather striking is the large number of references on the completely missing “yield” of the beehives in 1507 (Suppl. Table 2). To a lesser extent, the same difficulties were described in the bishop’s accounts in 1503. In fact, in 1507 only in very few cases were beehives sent from the villages to the castle of Eger: there were no bees at all to be transported in 16 out of 25 settlements, suggesting that the problem severely affected the north-eastern part of the Carpathian Basin, in 1507 at latest (Suppl. Table 2).

In 1507, the administrator of the Eger bishopric had to travel around 150 km to Pest, to buy wax: he bought 33 pounds for 4 (Golden) Floren(tini; hereafter Fl) in December 1507, for the needs of the castle and the church. The lack of honey and wax is further recorded in the 1508 accounts, mainly reflecting on the conditions of the previous year: in late March the bishop’s administrator again bought some pounds of wax, this time in Eger (Suppl. Table 1). Purchased wax—usually for a small price (a few denars)—also appears in the accounts in other years, without any information on the purchased quantities.

Similar to the mass loss of lambs, the severe lack of bees could be the consequence of a number of negative circumstances, and the general sensitivity of bees depends on the conditions of the present and the preceding year. Bees usually prefer not-too-long and not-too-cold winters: as presented before, there were cold and mild periods during both winters, early springs were chilly in Central Europe both in 1506 and particularly in 1507, and low temperatures could delay or block bee development (Fig. 1b).

If unfavourable winter or spring conditions are followed by hot and dry summers, this results in ageing bee families lacking a replacement generation: this significantly influences the present and the next year’s bee population, the honey and wax yields (see, e.g. Faluba 1959). For example, the great summer drought was blamed for the bad honey yields of 1718 in Oldenburg (Germany): the bees were not swarming, no bees could be seen in the fields and meadows (Kanold 1719). It is possible that the combination of cold winter periods, cool early springs and dry hot summer(s) and generally the dry year were responsible for the mass loss (or infertility) of bees. As no detailed accounts are available for 1506, it is not clear whether the problem only arose in 1507 or it was already present in 1506. Just like cabbage, honey was an important resource for the strengthening of the human immune system, particularly in winter times, and lacking also this basic victual might have had negative cumulative effects on human health.

Lack of fish in the River Tisza: an indicator of prolonged low water-level conditions In the oppressive picture emerging for 1507, fisheries were no exception. First, in early April 1507, the low quantity of caught fish, including the highly valued

sturgeon, was reported in the accounts of the Eger diocese. Later, on 2 October, the administrator again mentioned the low number of caught fish in this year. At that time, the most important fisheries of the bishops of Eger were in the River Tisza with sturgeon-catching places in (Hejő)Kürt and Tiszanána (Sugár 1979; Fig. 2).

The low quantity of fish in the Tisza is usually the consequence of prolonged low water-level conditions, while sometimes it is due to very great, prolonged floods. However, despite detailed documentation, no flood was reported at the Tisza fisheries since 1501, and in spring, before the sturgeons were expected to arrive, the weirs were repaired, an activity usually requiring dry conditions (e.g. Répássy 1903; Sugár 1979). Thus, the low numbers of fish in early and late 1507 must reflect the insufficient precipitation, both in 1506 and 1507, over the extensive river catchment area that comprises the present-day East Slovakia, South-West Ukraine, North Romania and North-East Hungary.

Tax relief, common works and charity: administrative, socio-economic response

Many of the socio-economic response types, usually applied in times of difficulties, appeared in the documentation in 1506–1508. A typical response on the shortage of goods was to travel further and pay more to get the desired products. Such a case was documented in 1507, when the administrator of the Eger bishop travelled to Pest, to buy a large quantity of expensive wax (33 lb).

Apart from the “usual” references in testaments on particular charity donations to the poor and to hospitals (e.g. HNA DL 46743), another form of socio-economic response was the increase of charity expenses. A typical, feature of paternalistic care is illustrated by the bishop’s administrator refusing to stay in the impoverished villages in 1507 to avoid placing additional stress on the serfs’ resources (Suppl. Table 1).

Common types of social response were partial or full tax relief, postponement of the tax payments, and the replacement of tax with common works. Numerous examples are available in the episcopal accounts when, due to the loss of the harvest, the tithe was postponed for half a year or sometimes even a whole year. For example, the 1506 lamb tithe was due only in 1507, the grain tithes of 1507 in the Humenné and Zemplín districts were postponed to 1508, and because of the destruction of (cereal) harvest caused by the great drought, Prešov was allowed to pay the grain tithe, due in July, in December 1507 (Suppl. Table 1).

Other popular method was the partial relief of a tax type: in case of the settlements of the Eger bishopric, this usually meant a partial vine or grain tithe release. For example, in March 1507, due to the great destruction in the vineyards, Tolcsva in the Tokaj-Hegyalja wine region received a 12 Fl relief from the wine tithe, whereas in April the residual tax of

the Felnémet villagers was abolished. A 10 Fl partial relief of the wine tithe was decided in February 1508 in the wine region of the Debrő valley near Eger. In July 1507, Bardejov received partial tax relief as a compensation for the grain harvest failure. Sometimes the tax relief made little difference: for example, in late November 1507, due to the great destruction caused by hail in the previous summer, Pásztó received 1 Fl relief (Suppl. Table 1).

Full tax relief was rare and mainly tax types of smaller sums were concerned: in our case, some of the episcopal and royal taxes (e.g. *census*, *dica*). In full tax-relief cases, in the Eger accounts, poverty was the most often referred to major reason, which may have been a reflection of multiannual problems. For example, because of their poverty, the *census* was fully waived for the people of Cegléd (burnt down in April 1507) and (Felső)Tárkány in early October 1507; the latter did not have to pay the *census* in 1508 either and with Harsány it was also exempt from the *dica* (see Suppl. Table 1).

A clearly significant crisis developed along the southern borders and was described in charters by the king, asking for money from royal towns and high clergy. Apart from the financial difficulties of the treasury being unable to pay the soldiers on time already for years, some interesting details are also worthy of consideration: the king referred to the very high prices and the urgent need of soldiers and inhabitants in the south in 1506–1508. His “crisis reports” are also supported by the local sources from Arad town in the South-East Great Plain where, due to the great dearth and the poverty of the locals, no food or money as a tax was collected in 1506. This happened in years when, because of a peace treaty, no major Turkish attacks were documented (Házi 1928; Simon 2006; Domokos 2015; HNA DL 93727, 25453, 102313, 46833).

Further type of tax decrease was the common or public works. For example, villagers (e.g. of Felnémet and Tárkány) received partial or full tax relief in April 1507, as they worked on the reparations of the cathedral in Eger. Sometimes a combination of tax relief types was applied: for example, Tolcsva received partial tithe release not only because of their significant losses but also because they took an active part in the common works (hay mowing) in the meadows of the bishopric (Suppl. Table 1).

Taking into consideration the decreased quantity of tithe incomes and all the tax reliefs, especially in 1507, it is overall not surprising that the incomes of the Eger diocese were significantly lower in 1507 (15,993 Fl) than in the other years with full income registers such as 1493 and 1495 (20,840 and 29,446 Fl; data: Romhányi 2006). In general, even in case of severe damage, only partial tax relief was offered, or the tax payment was postponed, usually by half a year. Full tax relief was only applied in case of (longer-term) poverty, and mostly for taxes with smaller payments (royal taxes). In these years, little is known how the drought and bad harvest problems affected towns and the urban population—in the available

urban documentation no further details can be traced regarding drought-related difficulties.

Discussion

Drought and weather in Europe and in the Carpathian Basin in 1506–1507

No snow, only ice was recorded during the winters of 1506 and 1507 in the Bratislava accounts (AMB K61, 61) indirectly suggesting that, similar to the Czech Lands, the winters were predominantly dry in the Carpathian Basin. Spring 1506 was wetter, but the summer was hot and dry in most of Europe (Figs. 1a, b and 3a, b). Based on the poor fish-catching results reported in March 1507, similar to Italy and the Czech Lands, at least the second half of 1506 was dry in the east. The first part of winter 1507 could be frosty, while the rest might be mild and dry.

While in summer 1506 the OWDA suggests dry conditions in most of Europe, during the summer of 1507, drought is restricted to the Alps, Italy, most of the Carpathian Basin and the Northern Balkans. Average or wet conditions prevailed in the rest of Europe, with a particularly wet Eastern Europe, Baltic region and Scandinavia. Cool and sometimes rainy conditions in the German and Czech areas in summer 1507 shows clearly opposing patterns to the hot and dry (spring–summer) weather that prevailed in Italy, the Carpathian Basin and partly in Poland, France and Switzerland (Fig. 1a, b). In Poland, this year was clearly drier than 1506, and August was particularly dry, especially in Cracow, where only four days with downpours were described (Limanówka 2001; Brázdil et al. 2013b; Glaser 2013; Fig. 1a, b).

Nonetheless, such a difference is not without precedence. For example, African heat can sometimes reach the Carpathian Basin in summer, which, blocked by the Carpathians, may then stay for weeks (e.g. in 2007, 2015: Russo et al. 2015). In these cases, the regions over the Alps, the area of the Central European reconstruction, are less or not affected—or even negatively affected, as happened in 2007 when, parallel to the extreme heatwave in the Carpathian Basin, temperatures notably cooler than usual developed in and over the Alps (21 July 2007: Suppl. Fig. 5). In such cases, as happened for example in 2007, a cool (and wet) summer may occur in Northern Europe—in our 1507 case these cool–wet conditions were probably responsible for the bad harvest and great difficulties reported in Sweden.

With regard to the spatial extension of the drought in Hungary, Kakas mentioned extraordinary, countrywide problems in 1507. The Eger episcopal accounts provided ample information on the great drought and destructive convective events in the central and north-eastern parts of the Carpathian Basin, and the low water levels of the Tisza in autumn 1507

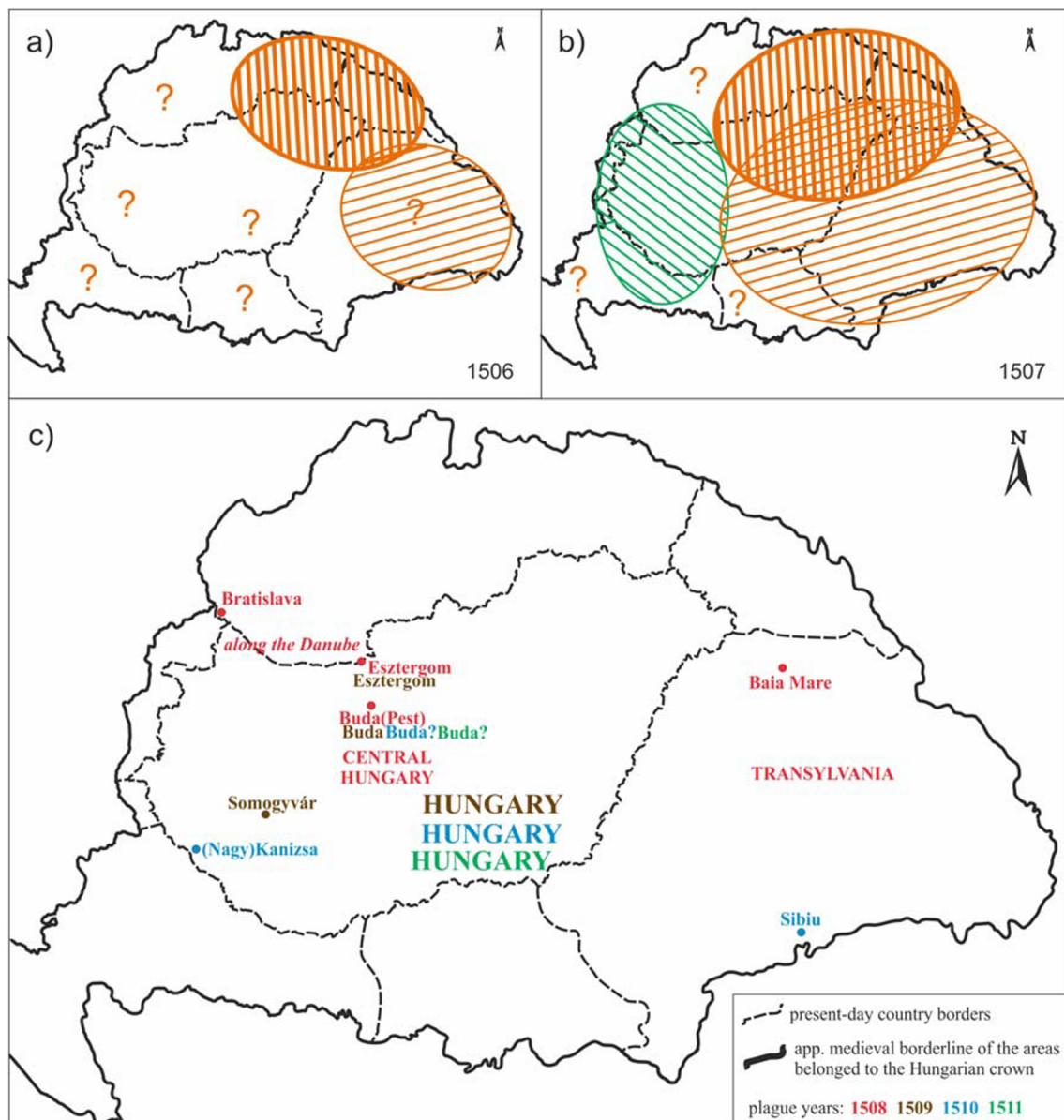


Fig. 3 The possible extension of drought in 1506 (a) and 1507 (b) in the kingdoms of the medieval Hungarian crown (thick orange stripes, strong drought reported; thin orange stripes, indirect evidence on drought; green

stripes, weakly or unaffected by droughts); c) plague epidemics reports in 1508–1511 (red, 1508; brown, 1509; blue, 1510; green, 1511)

further support the drought statement in North Transylvania (Fig. 3b). Based on the available documentary evidence, we can also state that in the north-east, in present-day North Hungary and Eastern Slovakia, and especially in the hilly areas east to the Tatra Mountains, the drought in 1507 was more severe than the OWDA suggests.

Considering great droughts of the early modern period (e.g. 1585, 1616, 1717–1718, 1790–1792, 1841–1842, 1863, e.g. Érkövy 1863; Csáki 2010), when drought was reported in the north-east, drought also prevailed in Transylvania and the Great Hungarian Plain. However, only an uncertain statement (Miles), probably supported by the export prohibition of cattle in 1507, approves the occurrence of a drought in Transylvania,

and the rather indirect documentary data and the OWDA evidence suggest similar conditions for the Great Hungarian Plain (Fig. 3a; Suppl. Fig. 1).

In West Hungary and Slavonia, no source refers to drought in 1506 or 1507, while the OWDA suggests a moderately dry (spring–)summer in West Hungary and drought in Slavonia in 1506, and notably dry conditions in 1507. According to the OWDA, the regions most affected by drought in 1506 and 1507 were the southern parts of the Carpathian Basin, including the south-west, and the southern military defence line of Hungary and Slavonia against the Turkish Empire. In the south-eastern part of the Great Hungarian Plain (Arad), significant food shortage and poverty were reported in 1507,

making it impossible to pay taxes in crops or money; as this occurred in a multiannual period of peace between Hungary and the Turkish Empire, (severe) harvest problems could be a contributing factor to the grave problems.

Although some of the documents directly mentioned the great drought of the year, 1507 is mainly described in Hungarian sources as an agricultural drought (i.e. bad harvests, “burnt” spikes), with special emphasis on the central and north-eastern regions of medieval Hungary. Evidence on poor fish-catching results in March and September reflect prolonged low water levels (hydrological drought) of the same region in 1506 and 1507. Dates of vineyard works, bad harvest and the shortage and high prices of crops, bread, wine and especially of hay, poverty, fires and related administrative responses provide ample evidence on the groundwater drought and socio-economic drought (Fig. 3b).

Drought, dearth, hard winter and the subsequent 1508–1511 epidemic

In recent years, a growing number of publications are available discussing the relationship between plague outbreaks, food crisis and environmental/climatic conditions. As a novel research, Schmid et al. (2015) suggested the maritime reintroduction of plague from Asia to Europe, but excluded the early sixteenth-century epidemics for being one of the recurrent outbreaks. Significant food shortages and subsistence crises are usually linked to plague occurrences, as malnutrition provided a favourable background to the spreading disease. Mainly caused by unfavourable weather, similar conditions were described in Hungary in 1506 and 1507.

With regard to the general weather background of epidemic outbreaks, in medieval England warm, dry conditions prevailed in most plague years, and usually a change in conditions from wet to dry (Campbell 2016; Pribyl 2017). In China, a negative correlation was detected between temperature values and epidemic outbreaks at country level, but even if climate change might have prepared the ground for epidemic outbreaks, economic well-being was the main trigger that led to increased vulnerability of the population to the infectious diseases (Pei et al. 2015; Lee et al. 2017). Based on data from Great Britain, France, Germany, Spain and Italy, recent investigations suggest that in the period 1347–1800 drought was primarily responsible for plague outbreak synchrony in Europe. Apart from local outbreaks, drought usually preceded major European plague outbreaks: “the occurrence of drought and the subsequent reinforced rainfall dampened both the rodent community and human society and boosted the number of fleas that carried plague” (Yue and Lee 2020).

In Hungary, one of the greatest late medieval pestilence occurred between 1508 and 1511 (Kiss 2020). Regarding the possible route of infection, in 1506, the outbreak was reported in Vienna and in 1507 in Cracow, while pestilence was

recorded in the Balkans in both years, similar to the Russian territories (Biraben 1976; Schmölzer 1985; Savignac 2016). In 1507, the disease was locally present in Hungary (Suppl. Table 1). Nonetheless, the first real outbreak is only known from October to November 1508, when the densely populated Danube valley between Vienna, Bratislava and Buda, the central parts of the country—in areas where a year before high prices were noted—and Transylvania in the east were already heavily affected. The great distance between the synchrony of autumn pestilence reports may suggest parallel outbreaks and infection routes within the country and/or an earlier start of the epidemics. Although this is the best-documented epidemics in late medieval Hungary, the full spatial extension of infected areas in the different years is unknown (Fig. 3c). Nonetheless, the relationship between insufficient food and water consumption as well as the importance of disinfection and quarantine was referred to by the doctor of Sibiu (historical Nagyszeben/Hermannstadt), the first in Hungary who, applying strict quarantine in 1510, was successful in fighting the disease (Saltzman 1510).

Even if no direct spatial relationship is detectable, the bi-annual drought, with consequent food-supply problems, dearth and poverty might have prepared the ground for the forthcoming epidemic in Hungary. There was also a clearly detectable change in prevailing weather conditions: the successive years with predominantly warm and dry conditions were followed by a cold, long winter and a wet year in 1508 with a (summer–)autumn outbreak and the quick spread of the disease. These conclusions show similarities to, for example, the great 1717–1720 plague epidemic (e.g. Csáki 2010), and the results are in agreement with the recent (Western, Southern) European and Chinese research, while opposing weather–epidemic outbreak relationship can be identified with the English conditions.

Conclusions

The (1506–)1507 drought is the best-documented drought in medieval and early modern Hungary. While mainly indirect evidence suggests that, just like most of Central and South Europe, the Carpathian Basin was hit by drought in 1506, Hungarian sources reflect more the drought of 1507. In the latter case, especially in summer, inverse weather patterns prevailed in Hungary compared with most of Central Europe, and weather conditions showed more similarities to those of North Italy than to the rest of Central Europe. On the one hand, the 1507 drought in Hungary meant insufficient amounts of precipitation in all seasons; on the other hand, heat and an increased number and severity of convective events were reported, “bad rains” that caused great further destruction to crops and vineyards. The extreme drought resulted in bad crop, hay, cabbage and grapevine harvests, and was

mainly responsible for a mass loss of livestock, and a lack of fish and bees—the loss of these domestic animal groups could as well be applied as a potential indicator of drought. Further probable socio-economic consequences were the increased number of (urban) fires, high market prices and restricted availability of some basic victuals, the multiannual poverty and reduced tax-paying abilities of the serf population. Apart from the unmistakable signs of social awareness (e.g. charity), typical responses of authorities were the postponing or lowering of certain taxes and/or the replacement of taxes by common works. The change in weather patterns with a long, cold winter and overall wetter year in 1508—combined with difficulties in food supply—might have provided a favourable background to one of the most severe plague epidemics in late medieval Hungary, with an outbreak in (summer–)autumn 1508(–1511).

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