Chapter 6
Temperature Extremes 1256–1431: Independent Evidence and Context

6.1 Temperature Extremes and Agricultural Production

As described in the previous chapter, spring and early summer temperatures were falling over the course of the Late Middle Ages in England. Except in extremely cold and wet years this would not have created major problems for the agricultural production,[1] because in general in southern England the growing season is of sufficient length for the corn crops. Temperature determines the grain harvest date, but exerts only a minor influence on the grain yield.[2]

Extreme temperatures, however, indicate extreme meteorological conditions in general, precipitation included. Such extremes were of course dangerous for the agricultural sector, and could ruin the crops for an individual year or, worse, for a sequence of years. In England cool conditions during the growing season often go hand-in-hand with raised levels of precipitation, whereas warm spring-summer conditions are more likely associated with drier weather. The grain crops, wheat, rye, barley and oats, favour different meteorological conditions, and the severity of the impact of heat, cold, rain or drought is dependent on the timing. Nonetheless in England's maritime climate the primary risk factor for agriculture is cold and wet weather during the growing season. Sequences of cold years frequently correspond with times of high grain prices and even famine. These temperatures consequently indicate weather conditions detrimental to crop growth.

The phases of high interannual variability of the growing season temperature 1315–1335 and 1360–1375[3] overlap partly with periods containing very cold years and also correspond with high grain prices. The frequent shifts in weather patterns and the prevalence of cold and wet years raised the vulnerability of medieval

[1] Campbell, Four famines and a pestilence, 10.

[2] Weather patterns that correlate strongly with high or low grain yields are described by Titow, Evidence of weather, 363.

[3] The years are generally known to have witnessed weather conditions rendering farming difficult, Ogilvie, Farmer, Documenting the medieval climate, 127.

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agriculture, because they prevented an adaptation of the agricultural production to the weather conditions.

Independent English documentary evidence for the extreme warm and cold reconstructed East Anglian spring-summers can not only provide more information on the meteorological conditions, but can also give an indication of the vulnerability of the agricultural sector in England during the medieval period and highlight wider societal impacts, particularly with regards to famine and susceptibility to epidemic disease. For the detection of poor harvests and price rises for grains the data by Phelps Brown and Hoskins, which have been reworked by Munro are used.[4] Apart from establishing the regional footprint of an extreme event, its spatial extension will be considered by comparing the reconstructed English temperature conditions to the temperature indices constructed by van Engelen, Buisman and Ijnsen in 'A millennium of weather, winds and water in the Low Countries'.

Independent contemporary evidence on English weather is provided in numerous narrative[5] as well as administrative sources. Britton's compilation 'A meteorological chronology to AD 1450' has been used as the starting point to seek out weather references in narrative sources. However, chronicles not listed in Britton have also been employed, as well as occasional weather references overlooked by Britton. All of Britton's information used in this work has been verified with the original source and the original text is used.

Evidence from administrative sources is mostly constituted by direct information on weather in manorial accounts. The largest surviving collection of these comes from the estates of the Bishopric of Winchester, which were mostly situated in south-central England.[6] The direct references to weather were collected by Titow in 'Evidence of weather in the account rolls of the bishopric of Winchester, 1209–1350' and 'Le climat à travers les rôles de comptabilité de l'évêché de Winchester, 1350–1450'. The first of Titow's works also includes material from Glastonbury Abbey. Information for Sussex was assembled in 'Late-medieval weather in Sussex and its agricultural significance' by Brandon.[7] The evidence for the Westminster Abbey manors in Hertfordshire, the most important one being Kinsbourne, comes from 'A Hertfordshire demesne of Westminster Abbey. Profits, productivity and weather' by Stern. Weather references from East Anglian accounts are also used throughout this chapter (Appendix 1), as well as the reconstructed East Anglian growing season temperature (Fig. 5.4, Appendix 4) and the precipitation index for July–September (Fig. 7.5, Appendix 5).

[4] Munro, Revisions of the Phelps Brown and Hoskins 'Basket of Consumables' commodity price series. The values are advanced by one year so that in this study they date to the harvest year.

[5] For an analysis of the sources available and the interconnection of some chronicles during the study period, see Gransden, Historical writing in England, vol. 1, 356–517 and idem, Historical writing in England c.1307 to the early sixteenth century, 1–248.

[6] Titow, Winchester yields, 38.

[7] When comparing the weather evidence from Sussex with other information, it appears that in Sussex, just as at Norwich Cathedral Priory (note 109 in Chap. 2), there was a dating problem in the early years of the reign of Henry IV, c.1400–1408. Hence the year of Brandon's weather evidence between 1400 and 1408 has been adjusted.

6.2 Warm Growing Seasons 1256–1431

6.2.1 Weather Conditions in 1267

For the warm growing season 1267 no additional English documentary evidence is available, but the Low Countries summer half year index agrees with the April-July mean temperature reconstruction and stands at maximum (III).

6.2.2 Weather Conditions in 1297 and 1298

The manorial accounts of the Bishopric of Winchester and the Westminster manors in Hertfordshire supply information on the dry conditions in 1297 and 1298. In both years the Winchester manors had to repair their ploughs which had broken during the summer ploughing because of the dry weather and consequently hard soil. Drought impacts on hay production and the productivity of pasture land were also common. The plough problems were repeated in the Westminster accounts for the growing season 1298 and in autumn a 'great drought' was noted.[8] The harvest in Norfolk and on a Winchester manor close to London was shorter than average in 1298 and hence also indicates dry weather in the harvest period. The summer half year 1297 scores III in the Low Countries and thereby confirms the reconstructed warm temperatures of spring and early summer in England, for 1298 no information is available. In 1297 the Norfolk barley harvest was poor; this is a typical drought impact.

6.2.3 Weather Conditions in 1304–1307

Another warm and dry phase were the years 1304–1307. In 1304 the evidence from Norfolk for a warm spring and early summer period is supported by other manorial accounts from the demesnes of Westminster Abbey. The manor of Kinsbourne reported a great drought for summer 1304, ploughs were broken. In the Low Countries the summer half year is indexed as 7. The harvest length in Norfolk 1304 was shorter than average as also in 1305 and 1306, thereby confirming dry conditions in late summer and early autumn in these years.

In 1305 another severe drought took hold in England. The manors of the Bishopric of Winchester and of Glastonbury Abbey report drought impacts. Ploughs broke frequently, the dairy production was low and pastures did not produce enough

[8] The 'great drought' either refers to autumn 1298 or spring/summer 1299, Stern, A Hertfordshire demesne, 93. In the light of the evidence listed above, it can be assumed that autumn 1298 is meant.

herbage. The Flores Historiarum also refer to heat and water shortage.[9] Whereas the heat is well reflected in the summer temperature index for the Low Countries which again stands at 7, the reconstructed temperature for East Anglia is below average. This underrepresentation of the summer temperature is connected to the winter 1304–1305 being long in Norfolk (Appendix 1) and consequently delaying the onset of the growing season. Norfolk's soils are also vulnerable to drought, which can result in a vegetation delay. The backbone of the East Anglian temperature series is the long harvest date series from the Northwest region, which is, however, situated on sandy soil close to the north coast and consequently not only more susceptible to drought than other Norfolk regions, but also suffers more than the inland manors from the cold north winds in spring time. In 1305 the combination of these factors resulted in northwest Norfolk producing the latest harvest date of all available harvest dates, which is unusual. Most Norfolk manors harvested around 1 August, whereas the Northwest region started harvesting 10 August. The temperature reconstruction, however, remains tuned to northwest Norfolk.

For 1306 the warm Norfolk growing season temperature went hand-in-hand with drought impacts upon pastures and dairy production on the Winchester manors, but conditions during the summer half year in the Low Countries were average.

In 1307 another warm growing season completes the run of dry and warm springs and early summers. In the Low Countries the summer half year was average, but the report of drought by a manor of the Bishopric of Winchester in Somerset and a probably dry late winter and early spring in Hertfordshire underline the dry and potentially warm conditions during spring in England. Conditions during the harvest, however, seem to have been very wet, the harvest was very long in East Anglia (Sect. 8.2).

6.2.4 Weather Conditions in 1318

Extremely warm and dry conditions returned to England in spring and summer 1318, just in the aftermath of the Great Famine. The year is part of the volatile weather conditions during the agricultural crisis 1314–1323 and is considered in detail in this context in Sect. 6.4.

6.2.5 Weather Conditions in the Mid-1320s

The April to July mean temperature 1326 is the second warmest in the reconstructed temperature series for East Anglia. The year is part of a severe drought phase in England and probably also in the Low Countries. Britton gives 1325 and 1326 as drought summers and the Norfolk harvests in those years were a rapid process.

[9] Flores Historiarum, vol. 3, 127–128.

Across the North Sea, the summer indices are both categorized as 9. The summer of 1324 was already good (7), and Britton states that several compilers also list 1324 as a drought year, but the only available medieval drought reference from England is non-contemporary, it is a copy of another chronicle which is actually describing 1326.[10] It is not supported by the administrative sources, the accounts of the Bishopric of Winchester are silent for spring and summer 1324 and in Hertfordshire there are merely indications for late winter or early spring, which was mild and dry. Unfortunately there is no harvest date for the reconstruction of the mean growing season temperature of 1324, but the East Anglian harvest was longer than average which is corroborated by a Winchester manor experiencing a rainy harvest.

The reconstructed East Anglian growing season temperature for 1325 is average, whereas it is very high for 1326. The Historia Anglicana, written decades later, describes the year 1325 as a time of extreme drought. The chronicle remarks on very low water levels in rivers and fountains, and the loss of domesticated and wild animals due to the lack of water. The heat and drought were so severe that the author thinks it fit to compare England to Africa.[11] Dry conditions were certainly present in East Anglia, which due to climate and soil is more vulnerable to drought than other regions of the British Isles. In East Anglia the growth not only of legumes, but also of oats, rye and grass suffered at least locally, ploughs broke in the hardened soil. Near Framlingham Castle in Suffolk holes were dug in the ground of a pasture to provide water for grazing animals (Appendix 1). The dry conditions put further pressure on the vulnerable dairy sector, and at Norwich Cathedral Priory the idea took hold to lease out the dairy production. The Winchester accounts list many drought impacts.

Nonetheless the drought reference in the Historia Anglicana could well be a summary of a drought description in the Annales Paulini, a London based chronicle, which actually details the conditions of 1326, and which was composed much closer to the events of the mid-1320s. According to the Annales Paulini a drought had taken hold in England, not only in summer, but also during other seasons, and had forced people to lead their animals to a water source for three or even four leagues. Waterbodies, rivers and wells, which before had withstood drought, now dried up. Low water levels caused a disruption of water transport and the dying off of fish. The water of the Thames was salty for almost the whole year, that means the water level was so low in London that sea water could push up the river channel through London Bridge. The fruit and vine harvests, however, were very good.

[10] Britton, Meteorological chronology, 134. Britton collected the drought reference from Burton, Chronica monasterii de Melsa, 349, but also suspects misdating. The Melsa Chronicle was written around 1400 and its interest in weather is normally very limited. The reference to a drought 1324 is also not independent, but very close to the wording of the various London chronicles, as the Chroniques de London, 50, which is cited below and which is an older text. The reference of the Melsa Chronicle is an abbreviated version and it excludes the paragraph on the salt water in the Thames, but includes the fires at Royston, Wandsworth and the Abbey of Croxden without giving the date for the conflagration.

[11] Walsingham, Historia Anglicana, vol. 1, 177. He is citing a classical text actually referring to Ethiopia, but in this context Ethiopia represents Africa.

> Anno Domini MCCCXXVI, et anno regni regis Edwardi XIX […] Eodem anno tanta siccitas per totam Angliam fuit, tam in aestate quam in aliis temporibus illius anni, quod homines duxerunt sua animalia ad aquandam, in aliquibus partibus regni, per iii. leucas vel iiii^{or}. Fontes et torrentes, putei et paludes, qui antea nunquam siccitatem sustinuerunt, omnino exsiccati fuerunt. Stagnum de Neuport in comitatu Essexiae, continens in circuitu unam leucam, siccatum fuit, ita quod pisces omnes perierunt. Eodem modo aqua de Haveringmere, aliquando portans magnas naves, in tantum fuit subtracta quod vix potuit parvum batellum portare. Et Thamesis fluvius fere per totum annum salsa fuit. Hoc anno maxima fuit copia frugum et vini.[12]

This description of 1326 in the Annales Paulini is echoed in the Chroniques de London, another chronicle from London. This text adds that as a consequence to the salty Thames water, the London citizens had to content themselves with salty ale. Several places fell victim to fire in June.

> xix [Edward II]. En cele an fut graunt secheresse de rivers et de fountaigne, issint qe il avoit graunt defaute de ewe en plusours paiis. En cele temps, devant la feste seint Johan, ardoit la vile de Roiston et partie de Wandlesworth, l'abbeye de Croxtone pres de Leicestre, et autres arsouns furent adonke en Engletere. En cele temps, pur defaute de ewe douce, la mer surmonteit issint qe le ewe de Tamyse fut salé, dont mult de gentz se pleinoient de la servoyse fut salé.[13]

Manorial accounts give further detail. Not only is the list of drought references in the Pipe Roll of the Bishopric of Winchester much longer in 1326 than in 1325, but by 1326 the cumulative drought stress posed a threat even to trees in East Anglia. Norwich Cathedral Priory tried to sell a high quantity of desiccated ash-trees at its main wood, Hindolveston in northern Norfolk (Appendix 1). Lack of pasture limited the production of cheese in wide areas of England, as reported for southeast England, by the Winchester manors and by a manor of Christ Church Canterbury also situated in the Winchester region.[14]

The heat and drought of 1326 stretched to Ireland, because the London reports are echoed there:

> Annus autem iste siccus fuit ultra modum Hybernie consuetum; sic quod in yeme quasi parum pluvie fuit, in vere estate et autumpno quasi nichil, tanta fuit siccitas et tantus calor, quod fontes et magni rivuli (ubi semper emanabant aque copiose) penitus siccabantur.[15]

Hence, on the British Isles, the dry and warm conditions in 1326 were considerably more pronounced than in 1325. Notwithstanding the unusual weather grain

[12] Annales Paulini, 312–313.

[13] Chroniques de London, 50. The chronicle was compiled in the mid-fourteenth century. For the genesis, sources and interconnection of the London chronicles, see McLaren, London chronicles of the fifteenth century, 15–48, and including also earlier specimens from the thirteenth century onwards: Gransden, Historical writing in England, vol. 1, 508–517. On the perception of weather in the London chronicles, a popular subject, see McLaren, London chronicles of the fifteenth century, 71–72.

[14] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305-1386.

[15] Clyn, Annalium Hiberniae Chronicon ad annum MCCCXLIX, 18.

prices were low in both years, but in the comparatively dry climate of Norfolk with its often well draining soils, barley harvests were poor.

After a short break in the dry and warm conditions in 1327, these returned in 1328. The reconstructed temperature is high and the Low Countries temperature index for the summer season is above average (7). Again the warm weather stretched to Ireland, where non-contemporary information also hints at summer temperatures high enough for the formation of destructive thunderstorms.[16] Across England, in Norfolk and around Winchester, the harvest was short, so the late summer must have been dry. The grain prices rose sharply in the year following the harvest 1328, but it is unclear, if the (winter) grain suffered during the long winter 1327–1328, which in its later stages was very hard on the Winchester manors, or during a drought at a critical phase of crop development or from other conditions.

6.2.6 Weather Conditions in the Early 1330s

During the first half of the 1330s, 1331–1334, England experienced a sequence of dry and warm springs and summers. 1331 was a major drought year. According to Merle there was only light rain in spring, that did not penetrate the ground,[17] but winter had been very wet so that flooding was frequent on the Winchester manors. The Annales Paulini specify that before c.17 June no rain had fallen for 15 weeks. That would indicate that in the London region precipitation was very low since the end of February. Shortly before the 17 June rainfall set in.[18] After the wet and cold weather in 1330 and the wet winter, the drought 1331 took people by surprise and references to drought impacts are plentiful in the Pipe Roll of the Bishopric of Winchester: ploughs were broken, pasture and hay were scarce. Similar problems were recorded in the rolls of Christ Church Canterbury.[19] On the Westminster manor of Kinsbourne drought reduced the pea harvest. The van Engelen et al. summer index scores 8, the English April–July temperature was average. Most likely the drought held back the growth of vegetation. The combination of wet and probably also little seed corn from the harvest 1330, wet weather at the sowing time of winter wheat and rye at least on the Winchester manors in the west of England, a very wet winter and then the prolonged drought in 1331 were very problematic for grain cultivation. Prices for wheat and barley rose in the year following the harvest 1331, in Norfolk the barley harvest was very bad indeed.[20]

In 1332 the dry conditions were weaker, but it was a very warm growing season, and summer was very dry. All East Anglian harvests in the first part of the 1330s were shorter than average, but 1332 was the quickest amongst them. The speedy harvest

[16] Annals of Loch Cé, vol. 1, 608–609.

[17] Merle, Consideraciones temperiei pro 7 annis, under June 1340.

[18] Annales Paulini, 354.

[19] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386.

[20] Hallam, The climate of eastern England 1250–1350, 129.

was a widespread phenomenon, as it was also observed in Staffordshire.[21] References to dry weather in winter and during the growing season come from the Winchester and Westminster account rolls. The summer in the Low Countries stands at 6.

April–July mean temperature in 1333 was even higher than in 1332. In this year the summer warmth stretched at least from the Low Countries (index 8), to Ireland, from where a temperate summer and low grain prices are reported.[22] April was dry in England.[23] Several Winchester manors experienced difficulties with the ploughs and pastures because of dry weather.

The year 1334 was rather unremarkable. The reconstructed temperature is average,[24] the summer half year across the North Sea is indexed as 6. The East Anglian harvest was shorter than average, indicating low precipitation levels around harvest time, but this was not a severe drought.

6.2.7 Weather Conditions in 1354

Spring and early summer temperature 1354 was high, despite the preceding winter being hard and long and delaying the start of the vegetation growth, as information from accounts of Christ Church Canterbury[25] and of the Bishopric of Winchester point out. For the following seasons hardly any information is available for England in this year. Some rain hindered the hay harvest on the Winchester manors, and in the Low Countries the season was average. However, in later summer, the harvest time was dry in Sussex, the harvest length in East Anglia normal. Further west, Winchester manors report high levels of rainfall that set in during the harvest, causing a long and expensive harvesting process. Considering the dry harvest weather in Sussex and the average harvest length in Norfolk, it is likely that the rain arrived after the harvest in southern and eastern England was finished, i.e. after early September.

6.2.8 Weather Conditions in 1361

1361 was an exceptional year, the earliest harvest in the whole series 1256–1431 took place in 1361. In fact across large parts of Europe there is ample evidence for a very warm spring and warm summer, which led to an early vine harvest and in some regions damaged the grain harvest.[26] In the Low Countries the year was clas-

[21] Lynam (ed.), Croxden Chronicle, ix.

[22] Grace, Annales Hiberniae, 128.

[23] Merle, Consideraciones temperiei pro 7 annis, under December 1342.

[24] Most harvest dates for 1334 are on the 1 August. This is somewhat unusual and it appears that they were reduced to a common denominator for convenience purposes.

[25] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386.

[26] Alexandre, Le climat en Europe, 490–491 and Glaser, Klimageschichte, 67.

sified as 8. For England John of Reading describes a drought, that set in towards the end of May:

> [Anno gratiae MoCCCLXI] Postea, evolutis diebus sex, vio videlicet die Maii, in vigilia Ascensionis Dominicae, […]. Sequebatur siccitas nociva, et ob defectum pluviae frugum, fructuum ac feni magna sterilitas.[27]

This is supplemented by the manorial accounts from Sussex and of the Bishopric of Winchester, which specify drought conditions, though not severe drought, and present here one of the very rare temperature references, noting also problems 'pro magno calore in estate'.[28] Portents recorded by John of Reading for continental Europe are likely to be connected to the presence of Sahara sand in the atmosphere and thereby indicate a southerly flow of air that contributed to the heat. In late May a blood rain fell in Burgundy, which could well have been rain mixed with Sahara sand. In Bologna a bloody cross was said to have stood in the sky for hours, this phenomenon might also have been linked to a raised amount of particles in the air.[29] According to John of Reading the heat continued in England into modern day autumn: after Michaelmas the roses flowered a second time and the birds bred again.[30] In this year a new fashion of 'indecent' – short and tight – clothing appeared, which made moralists fear for the worst,[31] and even though conservative chroniclers did complain about the introduction of new continental fashion at least since the marriage of Edward III to Philippa of Hainault in 1328, this sudden surge of the popularity of provocative garments in 1361 must have been linked to the unusually warm summer season.

The worst did indeed befall England: in this year the people of England and other European countries had to realize that the Great Pestilence had not been a singularity. The second national outbreak of plague affected England in 1361, it began in the south, then moved northwards, and caused a high death toll (Chap. 10).[32] Where the plague coincided with harvest time, the harvesting process was disturbed. This was a widespread phenomenon. In southern England, on the Winchester manors, harvests costs were raised '[…] propter pestilentiam subito supervenientem in autumpno.' A similar situation prevailed in southeastern England; on a manor of Christ Church Canterbury harvest costs were also high, because additional help had to be hired due to the epidemic.[33] The plague moved into Suffolk in late summer and autumn,[34] and probably affected Norfolk around the same time. In Gnatingdon, in

[27] Reading, Chronica, 148–149.

[28] A direct reference to the high temperatures is unusual and underlines the severity of the conditions. Normally early documentary sources focus on hydro-meteorological extremes, because of their greater impact upon agriculture and the wider economy, Pfister et al., Documentary evidence, 2.

[29] Reading, Chronica, 149.

[30] Ibid., 149.

[31] Eulogium, vol. 3, 230–231.

[32] Continuation of Higden, Polychronicon, vol. 8, 360.

[33] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386.

[34] Bailey, Medieval Suffolk, 183.

northwestern Norfolk, the harvest took an extraordinary long time, although other, less isolated Norfolk manors were not affected in this manner and had harvests of average length. Grain prices rose over the agricultural year 1361–1362 and it is likely that the drought impacts and the interruption of harvest work and transport caused by the plague played a substantial role in this price rise.

6.2.9 Weather Conditions in 1365

For the events in 1365 see Sect. 8.4.

After 1365 the reconstructed temperatures drop. The warmest years of this subperiod were 1371, 1385, 1390, 1400, 1409 and 1431, although they do not reach the temperature levels of extremely warm growing seasons before 1365. These warm springs and summers mostly went unnoticed in the narrative sources in England.

6.2.10 Weather Conditions in 1371

During the warm April–July period 1371 the Low Countries summer half year scored 7 and in Sussex and Hertfordshire spring was dry. In Sussex a wet harvest followed, in East Anglia the harvest was longer than average. The rain may have affected East Anglia, too, but more likely this year's grain crop was a good and bulky one, since the grain prices fell from a very high level after the harvest.

6.2.11 Weather Conditions in 1385

In the summer 1385 it was very warm in East Anglia and in the Low Countries (8). The year is part of a sequence of warm and dry years that are described in Sect. 8.3.

6.2.12 Weather Conditions in 1390

Another warm summer followed in 1390. The Westminster Chronicle records intense heat between the start of June and late August.[35] It was also warm in the Low Countries (8). The warm weather was accompanied by dry conditions in spring and early summer as noted or implied by the *compoti* of the Bishopric of Winchester and the manor of Kinsbourne. The situation in Norfolk was similar: in Sedgeford oats were yielding extremely badly, in Gnatingdon straw was lacking; on the well-

[35] Chronicon Westmonasteriense 1381–1394, 438.

draining soils of northwest Norfolk these problems were most likely drought impacts (Appendix 1). In the summer, severe thunderstorms with partly extremely heavy rainfall crossed England,[36] and the curse of the Late Middle Ages, plague, appeared again. The Westminster Chronicle attributes the outbreak to the prevailing hot weather and the corrupted air. Since the plague wave affected extensive areas and resulted in an excessive death rate, it was counted as the Fifth Pestilence; primarily the young were infected.[37] It remained present amidst famine disease in 1391 and returned in 1393 to Essex (see Chap. 10).[38] The harvest 1390 was longer than would have been warranted by the generally warm and dry summer and the low yields; this must have been connected to the disruption of the labour market due to the plague, the damage caused by the thunderstorms to the corn crops and the drought impacts, such as the stunted growth of the grain in Gnatingdon. In 1389 the harvest had already been deficient and in 1390 it was so poor that pestilence was followed by dearth.[39] The mayor of London imported grain from across the sea.[40]

6.2.13 Weather Conditions in 1400

The reconstructed mean temperature for 1400 is high and is reflected in the van Engelen et al. summer index standing at 8. After a warm growing season the harvest was marked by rain in many parts of England, evidence comes from the Winchester manors, from Sussex and from northwest Norfolk itself (Appendix 1).[41] Walsingham notes an epidemic for the summer,[42] one Winchester manor confirms a shortfall of labour due to pestilence at harvest time (Chap. 10).

[36] Chronicon Westmonasteriense 1381–1394, 444.

[37] Chronicon Westmonasteriense 1381–1394, 438, Walsingham, Historia Anglicana, vol. 2, 197.

[38] Hatcher, Plague, 58.

[39] Walsingham, Historia Anglicana, vol. 2, 195, 198. Blomefield, History of Norfolk, vol. 3, 113 speaks of raised mortality, also in Norfolk, due to a dearth lasting from the harvest 1390 the following one. He attributes the dearth rather to monetary policy, than to harvest failure.

[40] Walsingham, Historia Anglicana, vol. 2, 203–204.

[41] The account roll of Gnatingdon, NRO, LEST/IC/29, also mentions that the fallow was ploughed only twice. This is a low number and could indicate a period of dry weather that hardened the soil around May and June.

[42] Walsingham, Historia Anglicana, vol. 2, 246 and Annales Ricardi Secundi et Henrici Quarti, 332 (probably also a work by Thomas Walsingham).

6.2.14 Weather Conditions in 1409

The very warm growing season 1409 was preceded by a mild winter (3) in the Low Countries. Widespread flooding is reported for February.[43] In England winter conditions were comparable, flooding also took place in Sussex and eastern Norfolk (Appendix 1). However, spring and summer were dry in the Low Countries.[44] Drought affected Flanders between March and August, and April was also very warm,[45] although in general the summer half year seems to have been cool, standing at 4. It is possible that the warmer conditions further north over Scandinavia[46] reached also over the northern parts of the British Isles. In England one manor of the Bishop of Winchester suffered from rain at hay making time, but regions further south and east mirror the dry conditions of the Low Countries. In the Portsmouth area there was a lack of pasture.[47] Across Norfolk vetches and peas perished 'for the lack of rain' and because of 'dry weather' (Appendix 1). In northwest Norfolk, the summer ploughing of the fallow was carried out merely twice, which is atypical and could be connected to dried-up soils.[48] It appears therefore that a mild winter was followed by an early onset of the growing season, and dry and probably warm weather during spring and early summer resulted in a generally warm growing season in East Anglia. As in Flanders the dry conditions continued throughout August, because the harvest was short. The prices for wheat and barley rose considerably in the year following the harvest 1409, and even though the exact reason remains unspecified, the price rise is probably connected to the prolonged dry conditions impacting on the grain crops in eastern England. In some regions of England the water quality was badly affected during the dry and hot weather, the water gushed forth from wells red as blood and dysentery broke out.[49] Newcastle-upon-Tyne was visited by plague (Chap. 10).

6.2.15 Weather Conditions in the 1410s

The summer half year 1409 was warm and dry. As such, it was the first year that displays features common to the dry phase of the second decade of the fifteenth century. It is also the first year for which drought impacts on the agricultural production in Norfolk are numerous in the *compoti* rolls (Appendix 1). Until 1420 almost in every year remarks about peas and vetches perishing in the field, about the weak

[43] Alexandre, Le climat en Europe, 556–557.

[44] Camenisch, Endless cold, 1062.

[45] Alexandre, Le climat en Europe, 556.

[46] Luterbacher et al., European summer temperatures.

[47] Postles, Stubbington WCM 15389.

[48] Gnatingdon NRO, LEST/IC 34.

[49] Continuatio Eulogii, vol. 3, 414.

state of barley, rye and oats as well as about a lack of hay can be found in the East Anglian manorial accounts, partly even with the cause: drought. Only for 1411 no such entry survives. For a detailed description of the weather conditions during the 1410s, see Sect. 8.3.

6.2.16 Weather Conditions in 1431

The warm summer half year 1431 was also dry, as most years of the early 1430s (Sect. 8.3). In the Low Countries the index shows temperatures slightly warmer than average (6). Plague affected the estates of St Albans.[50]

6.3 Cold Growing Seasons 1256–1431

6.3.1 Weather Conditions in 1275

The first year in the April to July mean temperature reconstruction that was marked by a cold growing season is 1275.[51] As often is the case, no direct references to temperature are available in the contemporary narrative and administrative sources. Evidence about precipitation can be traced, however, and allows conclusions about the character of the growing season. The manorial accounts of the Bishopric of Winchester mention dry weather around April or May which impacted on the cheese production. Then the weather turned and rain hindered the harvesting process. Independently the Winchester Annals report continuous rainfall even earlier, for June, and then for winter:

> MCCLXXV: Eodem anno magna inundatio aquarum et pluviae continuatio mense Junii et pejus in hyeme.[52]

Walter of Guisborough notes, that in this year 'incepit communis scabies ouium in Anglia per loca diuersa'.[53] This outbreak of sheep scab might have been partly triggered by the wet conditions particularly in the winter months. The weather was foul not only in England. The East Anglian low growing season temperature is reflected in the summer half year in the Low Countries being categorized as I.

[50] Chronicon Rerum Gestarum in Monasterio Sancti Albani, vol. 1, 62.

[51] The growing season of 1258 which was a very bad year for farming in Europe due to a preceding volcanic eruption does not show as cold. This is in accordance with the general limited temperature response to this event, see Timmreck, Limited temperature response, L 21708. For the prolonged harvest in 1258, see Ch. 8.2.

[52] Annales Monasterii de Wintonia, 120.

[53] Guisborough, Chronicle, 215.

Although grain prices were high in the mid-1270s, no price rise can be connected directly to the harvest 1275.

6.3.2 Weather Conditions in 1283

For 1283 the sources are more informative. This time the cold and wet weather left a decisive mark on the agricultural and pastoral economy. In western England the harvest was ruined by the constant heavy rain in summer and at harvest time.

> Aestas tota, cum maxima autumni sequentis parte, vehementer continue pluviosa omnem fere spem satorum in viridi delusit in arido.[54]

Grain prices rose in the agricultural year 1283–1284 due to the disappointing harvest. Failure in the agricultural sector was joined by failure in the pastoral sector: the Dunstable Annals underline the detrimental influence of the continuous rainfall on the health of the lowland sheep and their consequent high mortality.

> Eodem anno ex maxima pluvia, quae quasi continue fuerat in aestate, fere omnes oves loca convallium pascentes, tantam humiditatem et pinguedinem interius conceperunt, quod generalis mortalitas ovium postea sequebatur: ita quod in partibus Dunstapliae vix habuimus ducentas oves in fine Martii subsequenti. Oves tamen nostre in Ciltria et in Pecco sanae et vegetes remanserunt.[55]

The Worcester Annals refer to much rain during summer and autumn 1284.[56] Britton ascribed this entry to 1283, which appears conclusive in the light of the other evidence.[57] In 1283 the reconstructed temperature for East Anglia is in accordance with the Low Countries summer index, which is equally cold, being I.

6.3.3 Weather Conditions in 1294

The cold and wet year of 1294 resulted in an agricultural crisis much more pronounced than 1275 or 1283. The summer half year was also cold in the Low Countries, it stands at a mere I. The mid-1290s still fall into the phase of high activity in historiographical writing in England, and especially the monastic chronicles provide plenty of information for the environmental conditions during the crisis.

The spring of 1294 was marked by severe weather. On 14 May London witnessed a snowstorm. It brought much snow and the strong wind damaged houses, trees and meadows.

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[54] Continuatio chronici Florentii Wigorniensis, vol. 2, 231.

[55] Annales Prioratus de Dunstaplia, 305–306.

[56] Annales Prioratus de Wigornia, 489.

[57] Britton, Meteorological chronology, 120.

> Rex Edwardus Primus, anno xxij. In this yere fel the grettest snowe that evere was seyn before this tyme; wherfore a vereyfyer made in metre thise vers:
>
> C'stino tiburci s'c'or' Valariani
> Nix cadit innanis vent' vehemens Borial'
> Emulsit silvas ussit quas rep'it herbas
> Edes dampnose detexit et impetuose
> Quas clam p'stravit sic plurima dampna patravit.[58]

Growing season weather conditions were detrimental to crop growth and prices for wheat as well as barley were already high before the harvest 1294. Many chronicles comment on the dearth,[59] which must have been largely due to the harvest 1293[60] and partly also to the prospect of a late and bad harvest in 1294. Scarcity and high prices reigned in England in the months before the harvest 1294 which due to the rain in August and September procured only little or no new corn before Michaelmas.

> Fames et inopia praegrandis per totam Angliam. Quarterium namque frumenti, quod vix et difficulter inveniebatur, ad xxiv. solid. per aliqua loca vendebatur; sed et mensis Augusti cum Septembri subsequente in tam imbribus continuis madidus fuit et pluviosus, quod usque ad festum S. Michaelis parum aut nihil de novo grano potuit reperiri. [61]

A very similar account is also in the Chronicle of Bury St Edmunds, which is situated in Suffolk, which was part of the East Anglian bread basket.[62] The late and long harvest, continuing in many regions of England at least till Michaelmas, is also reflected in the Norfolk precipitation index.

The Worcester Annals also ascribe the late cutting of the grain to the frequent rainfall. In western England the rain started in late June and continued until March 1295.

> Anno Domini MCCXCIV. […] Frequens pluvia maturitatem messis in tanto impedivit, ut quarterium frumenti pro xx. solidis Londoniis venderetur. […] A festo Sancti Johannis

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[58] Chronicle of London from 1089 [sic] to 1483, 35.

[59] Examples are: Guisborough, Chronicle, 252 and Annales Prioratus de Dunstaplia, 391.

[60] Since c.1290 the English weather appears very variable, the early 1290s show a tendency towards at least wet harvest times and partly also wet summers, see Britton, Meteorological chronology, 126–128. According to Campbell, Nature as historical protagonist, 289 all five harvests 1290–1294 were below average, 1293 was especially bad. Relating to 1293 Titow, Evidence on weather in the account rolls of the Bishopric of Winchester, 379–380, notes that the various grain crops ripened simultaneously which resulted in a shortage of labour on the Winchester manors. According to Ogilvie, Farmer, Documenting the medieval climate, 126 above average rainfall in May was followed by dry weather in June and again wet conditions in July and August. The April-July temperature reconstruction and the precipitation index for the period July–September show 1293 as a warm and rather dry summer season, but if winter and spring corn had to be harvested at the same time, this would have shortened the harvest and hence give the impression of a summer of below average rainfall.

[61] Continuatio chronici Florentii Wigorniensis, vol. 2, 273.

[62] Chronica Buriensis, 192.

> Baptistae usque ad festum beatae Mariae in Martio, in autumno metere vel in hyeme serere sicut oportuit, frequens pluvia non permisit.[63]

The Dunstable Annals connect the late grain and hay harvests to the 'intemperate air'.

> Item autumnus, propter aeris intemperiem, tardus erat, una cum tempore foenationum; et populus de anno subsequenti quamplurimum desperabat.[64]

This was not the end of the problems at the Priory of Dunstable. In summer 1294 the hay barn at Dunstable was destroyed by fire. In the context of the weather evidence for 1294 and the fact that the hay harvest itself was delayed by the weather it seems possible that the hay was stored too wet and then rotted. Decomposing hay can produce such heat as to ignite the hay and thus also the barn. The Dunstable annals also state that a new enclosure wall built in summer collapsed in winter 'propter aeris intemperiem in aestate', other enclosure walls shared its fate.[65]

The 'intemperate air' caused desperation among the people not only because it ruined the grain harvest and thus helped to maintain the high grain prices, but also because the unusual weather continued after the harvest throughout autumn and winter, hindering, as the Worcester Annals point out, agricultural activity. This lowered the chances of a good harvest in the following year.[66]

The rain in autumn and winter 1294 mentioned in the Worcester Annals, was responsible for inundations of the Thames at Bermondsey and Westminster in October.

> Anno Domini MCCXCIV., et anno regni regis Edwardi primi vicesimo secundo. Hoc anno gurges aquarum Thamisiae transcendit consuetos limites [xviii. die Octobris, et tunc accidit magna brecca apud Retherhithe], et planitiem de Bermundeseye et procinctum de Tothille superficialiter debriavit. Similiter et casas negotiatorum in nundinis Westmonasterii attingendo superius palos figere compellebat.[67]

The accounts of the Westminster Abbey manor of Kinsbourne in Hertfordshire also report a wet autumn and early winter.[68] Due to the partly heavy rain the wheat sowing rate had to be raised. With dearth conditions already present, this was surely not a cheap measure taken on the lord's demesne. If the peasant farmers still had the means to increase sowing rates likewise to ensure a better harvest in the following year, is open to doubt. The wheat and barley prices remain high for 1294–1295 as well as 1295–1296.

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[63] Annales Prioratus de Wigornia, 516, 519.

[64] Annales Prioratus de Dunstaplia, 391.

[65] Annales Prioratus de Dunstaplia, 388.

[66] The success of the next harvest also depended on the quality of the seed corn used. After a wet harvest as 1294 the seed corn would not have been good, and might partly also have been consumed by desperate peasants. Even without rain at sowing time, these factors might lower the yields in 1295.

[67] Annales Monasterii de Bermundeseia, 468.

[68] The Winchester roll for 1293–1294 is missing, see Beveridge, The Winchester rolls and their dating, 96.

6.3.4 Weather Conditions in 1314–1323

The next exceptionally cold Norfolk growing seasons fall to 1314, 1315, 1319 and 1323. The first two are connected to the Great Famine 1315–1317 which was embedded in the agrarian crisis 1314–1323. Therefore these years will be considered under Sect. 6.4.

6.3.5 Weather Conditions in 1330

In the summer season 1330 cool and wet weather returned. It affected wide parts of western and central Europe, where the vines did not mature or only with great delay.[69] In the Low Countries the summer was extremely cold, an index of 1. From May till at least October England and Ireland suffered from rains.[70] Due to the weather the grain harvest was late and took a long time in the area between south-east England[71] and the northern Midlands. In Norfolk it also rained at harvest (Appendix 1), the gathering of the crops lasted till mid-October,[72] and in the area of the Winchester manors until early November. Further north, at Croxden Abbey in Staffordshire, it only began at Michaelmas, which marked the end of a normal harvest season, and lasted even until late November. The Croxden Chronicle also gives another poignant illustration of the prevailing extreme weather: in November fresh peas in the pod were offered to the monastery instead of apples or pears.[73] In Ireland the rain and storms gave summer and autumn 1330 an almost wintry character and as a consequence the harvest failed, corn stacks in the field were scattered by the autumn and winter storms, and famine ensued.[74] The wine of low quality and quantity which was produced on the continent this year was imported into England, where the incidence of taverns selling overpriced and unwholesome wine greatly increased, so that royal legislation tried to fix the price at a 'reasonable' level.[75]

[69] Alexandre, Le climat en Europe, 450–451.

[70] Clyn, Annalium Hiberniae Chronicon ad annum MCCCXLIX, 22, Lynam (ed.), Croxden Chronicle, ix.

[71] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386.

[72] The *compoti* of Norwich Cathedral Priory are missing for this year, information comes from Kempstone NRO, WIS 06.

[73] Lynam (ed.), Croxden Chronicle, viii–ix. The content of the Croxden Chronicle was later used in Holinshed's Chronicles of England, Scotland and Ireland, vol. 2, 598.

[74] Clyn, Annalium Hiberniae Chronicon ad annum MCCCXLIX, 22.

[75] Cook (Bickerdyke), Ale and beer, 106.

6.3.6 Weather Conditions in 1335

After the warm and dry phase 1331–1334 (Sect. 6.2) the growing season of 1335 was exceptionally cold. No contemporary narrative sources supply information on the weather and its impacts, but the summer was also cool in the Low Countries (3). At the Westminster Abbey manor of Kinsbourne the harvest was wet and stormy in 1335. In the Low Countries, northern France and Germany storm and rain damaged the harvests and the sugar content of the vine harvest was low, the wine sour: it was a bad year for wine production.[76] In England a murrain decimated the cattle stock again.[77]

The English national grain price, although rising in the year following the harvest 1335, remained average, partly because by the mid-1330s deflation had struck. Also the Winchester yields did not diverge far from average,[78] but there is no information by Hallam about the barley harvest in Norfolk 1335.

Several London chronicles refer to great rains, high mortality amongst men and animals, and very high grain prices either in 1335, 1337 or 1338.[79] These London chronicles are mid-fifteenth century works closely linked to the English Brut.[80] In this case, however, no comparable reference is found in the English Brut or related texts, but almost exactly the same wording is used by the Polychronicon (in Latin) and its English translations for the Great Famine 1315–1317, raising the chances that the crisis described in the London Chronicles for a year in the mid-1330s is a transcription error,[81] and the problems of 1335 were not as severe as described by them.

6.3.7 Weather Conditions in 1348–1349

The arrival of the Great Pestilence in England in 1348 coincides with another cold mean temperature for April to July in Norfolk. The year was also marked by high rainfall levels, as was 1349. They will be analysed in detail under Sect. 6.5.

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[76] Alexandre, Le climat en Europe, 459–461, Glaser, Klimageschichte, 65.

[77] Slavin, Cattle plague, 178.

[78] The usually verbose *compoti* of the Bishopric of Winchester, record no information for the spring and summer 1335. Hence it is possible that the meteorological conditions in south-central England were not as severe as in eastern England.

[79] For the bad weather etc. in 1335, see Chronicle of London from 1089 [sic] to 1483, 55, and William Gregory's Chronicle of London, 79, which has an almost identical text. The Chronicle of the Grey Friars of London, 4–6 and McLaren (ed.), London Chronicle, 165 put the crisis to 1337 respectively 1338, where it does not fit with any other contemporary evidence.

[80] Gransden, Historical writing in England c.1307 to the early sixteenth century, 221.

[81] Higden, Polychronicon, vol. 8, 308–309, including medieval English translations. The problems probably occurred due the similarity in the regnal years and kings' names of Higden's reference to the Great Famine and the year 1335. The references fall to c. Edward II 10 in the Polychronicon respectively to Edward III 9–10 in the majority of the London Chronicles.

6.3.8 Weather Conditions in 1364

It is clear that the low average temperature for the growing season 1364 is not so much due to the weather during late spring and summer, but to the exceptionally hard and long preceding winter. In the Low Countries the winter 1363–1364 was also extremely cold, being indexed as 9, the summer half year 1364 was average. The hard winter is noted by the Winchester and Christ Church Canterbury manors as well as in Sussex. From Kinsbourne in Hertfordshire there comes evidence of 'severe weather' in late winter or early spring.

That the winter was long and stretched into March is confirmed by many English chronicles including John of Reading.

> [Anno gratiae MCCCLXIV] Quam forte gelu incipiens circa festum Sancti Andreae Apostoli, quasi in fine Novembris anni proximo praeteriti, perseverans usque quartum decinum kalendas Aprilis hujus anni, quod opera campestria artesque manuales plurimum impedivit.[82]

The long continuation of the frost hindered the field work and of course delayed the onset of the growing season. The following summer was largely unexceptional; the Sussex and Winchester manors supply no weather reference to it. However, John of Reading writes also about heavy hailstorms that killed animals in many parts of England, even though the hail did not diminish the corn and vine.

> [Anno gratiae MCCCLXIV] Immediate, diversis in partibus Angliae cecidere grandines quae fortia animalia occiderunt; attamen blada et vina abundabant, fructus vero aborum et fenum modice.[83]

The formation of convective storms indicates warm weather, but the summer warmth could not compensate for the late start of the growing season, consequently there was a very late harvest in East Anglia.

6.3.9 Weather Conditions in 1368–1370

The years 1368 and 1369 were classified by Britton and in the Sussex accounts as very wet.[84] In the agricultural year 1369–1370 the grain price rose dramatically. Crop failures are also recorded in the manorial accounts of Norwich Cathedral Priory for 1368 and 1369. After the harvest 1370 grain prices decreased, even though the growing season had been very cold. The meteorological conditions and their role in the harvest success and failure between 1368 and 1370 need to be investigated.

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[82] Reading, Chronica, 160.

[83] Reading, Chronica, 161.

[84] Britton, Meteorological chronology, 146 and Brandon, Late medieval weather in Sussex, 4.

The accounts of the Bishopric of Winchester report widespread continuous rain at harvest time 1368. The growing season, however, appears to have been rather unremarkable, one manor even refers to dry weather. The theme of drought recurs in the *compoti* of Kinsbourne in Hertfordshire, where ploughs broke, no surplus pasture for sale was available in springtime and the horses were fed oats longer than usual. From southeast England drought impacts are known.[85] The crop failures in East Anglia also relate closer to drought than rainfall impacts, although the cause of the problems is not mentioned (Appendix 1). On the freely draining soil of northwest Norfolk peas were lost when still green, the pea and bean harvests were disappointing, and the hay harvest was below average, so that *pulmentum* ('horsemeat') was used later as supplementary fodder. The number of fallow ploughings was reduced close to Norwich. Even though the area of the Winchester manors was subjected to long rainfall at harvest time, the harvest duration in East Anglia was average, indicating normal harvesting conditions. Therefore at least parts of spring and summer were dry in East Anglia; potentially the region also escaped the rain at harvest time. The growing season temperature was average to cool.

Rain was a much more dominant feature in 1369 than in the previous year. The Winchester accounts contain frequent flood references for the growing season. In Sussex flooding was severe 1368 and 1369. The Winchester manors and Walsingham describe the very wet conditions around harvest time; the rain damaged the crops and in the agricultural year 1369–1370 the price for wheat and barley rose steeply.[86] At a manor of Christ Church Canterbury the wheat was affected by mildew.[87] Nonetheless weather conditions were dry at least at one stage of the growing season in eastern England. At Kinsbourne in Hertfordshire dry weather is mentioned for spring, the pea seed dried up in the ground. During spring the draught horses were again fed oats longer than usual and in summer time straw had to be purchased. Similar impacts are recorded in accounts from northwest Norfolk for 1369 (Appendix 1). Peas partly failed, and probably in the winter 1369–1370 peas had to be given to the manorial livestock, because hay was scarce, indicating a small hay crop for 1369. Unsurprisingly the East Anglian growing season on the whole was warm. However, the wheat harvest was also bad in northwest Norfolk; this is not a classical drought

[85] Mate, Agrarian economy after the Black Death, 349.

[86] Walsingham, Historia Anglicana, vol.1, 309 and Chronicon Angliae, 65, the paragraphs are identical, both chronicles are connected to Walsingham. According to Gransden, Historical writing in England c.1307 to the early sixteenth century, 124, this text comes from the continuation of the Polychronicon to 1377, which might well have been another work of Walsingham, Continuatio Adami Murimuthensis, 205. In Britton the paragraph of the Chronicon Angliae is accidentally allocated to 1368, but this reference is in all three chronicles clearly dated to 1369. Also many fifteenth-century London chronicles report a 'dear year' around that time, obviously referring to 1369–1370, e.g. McLaren (ed.), London Chronicle, 171, Chronicle of London from 1089 [sic] to 1483, 68, William Gregory's Chronicle of London, 88, Chronicle of the Grey Friars of London, 4–6.

[87] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386. Regarding the general rise of fungoid diseases in the grain crops of eastern Kent in the second half of the fourteenth century, see, Mate, Agricultural technology in southeast England, 254–255. She concludes that a shift in climate as well as badly prepared fields before seeding contributed to the more frequent occurrence of fungoid diseases.

impact. Direct references to harvest conditions are not available for East Anglia and harvest duration was normal (Fig. 7.5). Consequently the region might have escaped the worst rainfall of 1369. The extent of the wet condition at harvest time 1368 and 1369 and during the growing season 1369 in southern England is difficult to assess. The summers in the Low Countries are average, and for 1369 even a good vine harvest in quantity and quality is reported for the southern Low Countries.[88]

It seems as if severely wet and dry phases were closely intertwined in 1369 and possibly also 1368, and it was this rapid sequence of extreme conditions that contributed to the harvest failure. The situation was aggravated by 1369 being the year of the Third Pestilence, which gained momentum around harvest time. Faced with a shortage of labour and plague-induced upheaval in the organisation of labour, a wet harvest was even more difficult to handle than under normal circumstances and part of the subsequent grain price rise must have had its root in the impact of the epidemic on the work force. These repercussions of the pestilence were not limited to the agricultural sector, but would have also affected the transport sector. Transport was under additional pressure from a zoonotic affecting 'larger animals', presumable cattle and horses.[89]

In 1370 spring and summer were cold in East Anglia and also cool in the Low Countries, where the summer index is 4. The preceding winter was somewhat colder than average in the Low Countries, being indexed at 6. Generally 1370 is an unremarkable year for the contemporaries, especially when compared to the inclement years before. Even the Winchester accounts are largely silent about conditions 1370. Late winter and spring were wet in Hertfordshire and in Sussex dry weather is said to have prevailed in summer, but autumn was rainy again. In East Anglia the harvest duration was nonetheless average (Appendix 6), and England-wide the harvest quantity was sufficient for substantially bringing down the grain price, even though it remained on a comparatively high level until the next harvest 1371.

6.3.10 Weather Conditions in 1374

The year 1374 was marked by a cool growing season and agriculture consequently suffered. In East Anglia the year had already opened badly. In 1373 a longer harvest duration hints at raised precipitation levels in the region, but the national grain price remained untouched by these problems.[90] The low growing season temperature in

[88] Alexandre, Le climat en Europe, 503.

[89] Walsingham, Historia Anglicana, vol.1, 309, Chronicon Angliae, 65, Continuatio Adami Murimuthensis, 205; the texts are as good as identical.

[90] Raftis, Ramsey Abbey, 258-259. Raftis indicates food shortages in East Anglia 1373-1374. He cites an unpublished chronicle manuscript (Fakynham MS held in British Museum). The text is in fact a chronicle of the Grey Friars in King's Lynn, and has since been published: Gransden, A fourteenth-century chronicle. Raftis listed the other meteorological events and the epidemics in the manuscript correctly, but overlooked that the food shortages did not affect East Anglia, but an English army in France.

England 1374 finds its equivalent on the other side of the North Sea, where the summer falls into the category 4. In general the grain crops and the vines in Europe were severely affected by the humid character of the year, particularly in southern Europe which was in the grip of a severe famine. Le Roy Ladurie suspects that the rains normally destined for England and northern France moved on a track further south in 1374.[91] Indeed in England not many weather references and no major complaints about rainfall are available for this year. The Winchester accounts contain no information on weather, even though the wheat harvest was far below average on the Winchester estates. In Sussex the summer appears normal. The Kinsbourne *compotus* implies some severe weather in late winter or early spring. The summer might even have seen some dry weeks in eastern England, in Kinsbourne pasture had to be purchased for the sheep. In Great Cressingham, on the edge of the sandy soils of the Breckland in western Norfolk, the wheat crop grew poorly, as on the Winchester manors. Indeed grain prices were up in 1374–1375. The cause of the problems in wheat growing is unclear, but Great Cressingham is vulnerable to dry weather. The Scandinavian summer 1374 was warm[92] and it seems possible that England lay at the periphery of the rains in continental Europe and the warm conditions further north. Latest in early winter the miserable weather caught up with England, for the fenland in western East Anglia, including the town of King's Lynn, but also for Sussex and Kent, storm and severe sea floods are reported; this was followed by hard frost until Christmas.[93] The mediocre harvest 1374 is the last before a sequence of bumper harvests which brought down the grain price in England during the second half of the 1370s.

Many cold growing seasons cluster in the following decades. In the context of the late fourteenth and early fifteenth century they are not extreme, but still remarkably cold. To them belong 1382 and 1383,[94] 1389, 1395, 1399,[95] 1401, 1402, 1406, 1411 and 1423.[96]

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[91] Le Roy Ladurie, Histoire humaine et comparée du climat 79–88.

[92] Luterbacher et al., European summer temperatures since Roman times.

[93] For East Anglia see Gransden, A fourteenth-century chronicle, 278 and for Sussex and Kent see Mate, Agrarian economy after the Black Death, 349.

[94] The cold reconstructed East Anglian growing season temperature 1383 is confronted with a summer defined as 8 in the Low Countries; for England there is evidence of dry conditions during growing season and harvest time (Sect. 8.3).

[95] The summer half year 1399 was average in the Low Countries, but the growing season in eastern England was cold. The year was preceded by a cold winter in the Low Countries, harvest time was rainy (Sect. 8.4).

[96] 1423 was an average summer half year in the Low Countries. The year was preceded by a hard and probably long winter with the potential to postpone the onset of the growing season in England and the Low Countries (Sects. 5.3 and 8.4).

6.3.11 Weather Conditions in 1421

In 1421 the harvest around Norwich was late and in the northwestern part of Norfolk indeed very late. The cold weather conditions were at least at harvest time accompanied by heavy rainfall; at Sedgeford flooding was even reported (Appendix 1). The harvesting conditions, rainfall impacts, extra works necessitated by the weather in Norfolk, but also on the Winchester manors, are described in Sect. 8.4. Additionally there was flooding of pasture land in the district of Flegg, on the eastern Norfolk coast, during the agricultural year 1420–1421. Although the Winchester yields were more than 15% below average for all grains, no major rise of grain prices follows the sodden harvest.[97] The summer was average in the Low Countries.

6.3.12 Weather Conditions in 1428

Finally with the year 1428 the Norfolk manorial accounts supply data for another year when a major agricultural crisis caused by a cold and rainy growing season and harvest struck not only England, but also central Europe. The Low Countries summer half year is classified as merely 2.

In England rain started around the end of March and early April. Meadows and pastures submerged by endless rain during the growing season are reported by the manors of the Bishopric of Winchester. In Sussex, too, the summer was excessively wet.

The rain and the ensuing agricultural failure as well as murrains are alluded to by various London chronicles.

> Anno vj^{to} […] This same yere fro the begynnyng of April into Halwemasse was so gret abundance of reyn, where thorugh nought only hey was distroied, but moche corn, for it reyned almost every other day more or lasse.[98]

In William Gregory's London chronicle is stated:

> Anno vj – Henry VI. And that yere hyt was a wete for hyt raynyd for the moste party from oure Lady Day in Lentyn unto the feste of Mychelmas nexte folowynge. And that yere there was a grete morayne of bestys, and pryncypally of schyppe, for the more party of alle Inglondem for scheppe deyde ynne every contray of Ingelonde.[99]

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[97] Across the Channel, in northern France food was scarce, particularly in the urban centres of Paris and Rouen, see Fagan, Little Ice Age, 83.

[98] Chronicle of London from 1089 [sic] to 1483, 116. Similar entry in another version of the London chronicle: McLaren (ed.), London Chronicle, 201–202.

[99] William Gregory's Chronicle of London, 162. The chronicle is organized in accounting years, which start at Michaelmas, 29 September. So the reference of the end of the rain at Michaelmas can simply indicate the end of the year and not necessarily the end of the rain. The type of sheep murrain is not specified in the text, but some animal diseases are triggered by rainy weather and long-term wet meadows, like liver fluke in sheep, Ollerenshaw, Climatic factors and liver fluke disease, 130–134.

According to the St Albans Chronicle the rain continued even until Martinmas.[100] The chronicle also describes how the first sheaves were brought into the barn on the 2 September (Gregorian Calendar: 11 September), and between the end of March (Gregorian Calendar: 8 April) and the 3 September (Gregorian Calendar: 12 September) there had not been three subsequent days and nights which had escaped the rain and wind.

> In crastino Sancti Egidii inducebantur garbae primo in horreum Sancti Petri, quia tempus pluviosum et incolis periculosum ab ultimo die mensis Maritii usque tertium diem mensis Septembris, ut non erant per idem tempus tres noctes et dies clare lucentes quin supervenerunt et venti cum porcellis, et imbres cum stillatione.[101]

In northwest Norfolk the harvest also started deplorably late on the 25 August (Gregorian Calendar: 3 September). This date is so late that it constitutes the highest positive deviation of the whole harvest date series. Extra harvest works had to be performed because of the rainy weather. Due to the rain and the shortness of the days, conditions were especially problematic at the end of the long harvest, which for the *famuli* of the manor of Sedgeford lasted until mid-October (Appendix 1).[102] In south-central England the Winchester manors also encountered harvesting difficulties caused by rainfall. It can be concluded that the rainfall continued at least to mid- or late October.

As a result of the ruined crop, prices for wheat and barley rose in late 1428 and in 1429. As it is put in William Gregory's London chronicle:

> Anno vij – Henry VI. And that yere hyt was a dyre yere of corne and pryncypally of whete and of alle maner of of vytayle, for a buschelle of whete was worth xx d.[103]

Times were hard.

6.4 Weather Conditions During the Agrarian Crisis 1314–1323

The very cold growing seasons of 1314, 1315, 1319 and 1323, as well as the warm year 1318 are related to the Great Famine and the prolonged agricultural crisis in its aftermath. The Great Famine 1315–1317 has been detailed in its various socio-economic aspects by Lucas, Kershaw, Jordan and Desai.[104] Whereas Kershaw and Desai concentrate on England, Lucas and Jordan also provide a comprehensive outlook on the continental conditions. Lately, Campbell and Slavin have turned their

[100] Chronicon Rerum Gestarum in Monasterio Sancti Albani, vol. 1, 26–27.

[101] Ibid., 27.

[102] NRO, LEST/IB/68. Most other harvesters left the fields by the end of September.

[103] William Gregory's Chronicle of London, 164.

[104] Lucas, The Great European Famine; Kershaw, The Great Famine and Agrarian crisis in England; Jordan, The Great Famine; Desai, Agrarian crisis in medieval England.

attention towards the same subject.[105] However, a more in depth analysis of the English weather conditions for the famine period and subsequent years is required. As Kershaw stated, a number of chroniclers are not very accurate in dating the consecutive phases of the Great Famine.[106] The same doubts are uttered by Britton with respect to weather,[107] and so for a chronology of the weather conditions it is best to rely on information from administrative sources, as these were produced regularly and close to the events, so doubling and misdating is avoided, and they report the conditions objectively.[108]

According to the manorial accounts already 1313 did not offer ideal conditions for the grain harvest. Although the reconstructed East Anglian growing season temperature was average, as was the Low Countries summer half year, several manors of the Bishop of Winchester experienced problems with harvesting because of rain. The year 1314 then marks the beginning of the agricultural crisis. The growing season was cool and the harvest time was beset by rain.[109] In East Anglia the harvest was longer than average. The Winchester manors as well as Monks' Grange near to Norwich complained about rain during harvest time; in northern Norfolk, on Cromer Ridge, rain and storm caused problems and the growth of oats was hindered by water (Appendix 1). Two Winchester manors state that the harvest was not finished before the end of September or later. When famine conditions arose in 1315, they came not without warning: the cumulative effect of the problematic harvest of 1314, the disastrous harvest 1315 and of the sheep murrain taking hold in England 1315–1317, has also to be taken into account.[110]

For the crisis years 1315–1317 only few accounts of Norwich Cathedral Priory survive, but those that remain clearly reflect the cold and wet conditions of the summer half year 1315: the grain harvest was very late as well as long. The index for the Low Countries stands only at 2. For 1315 plenty of independent documentary evidence is available. The Winchester accounts present a litany of rainfall and flooding references and impacts for the growing season and harvest time. They are joined by

[105] Campbell, Great transition, 191–198, Campbell, Nature as a historical protagonist, 287–293. Slavin studied the effect of the Great Famine in Norfolk in his thesis, Feeding the brethren, 128–135 and in general in idem, Communities of famine.

[106] Kershaw, The Great Famine and Agrarian crisis in England, 88.

[107] Britton, Meteorological chronology, 70.

[108] As Hallam, The climate of eastern England 1250–1350, 124 points out, in these times of upheaval in the English political scene, accounts of bad weather in chronicles or annals could be used as symbols of misgovernment or other political problems.

[109] Several chronicles claim that the rain set in May 1314 and lasted till Easter 1315, but as Kershaw, The Great Famine and Agrarian crisis in England, 88 explains, this is probably misdated and should refer to 1315–1316. He is very likely correct, because the manorial accounts for 1314 refer to a wet harvest, but not to a wet growing season, which makes continuous rainfall between May and July 1314 rather unlikely. In 1315 then the *compoti* are full of references to rain for this period.

[110] Kershaw, The Great Famine and Agrarian crisis in England, 88–9, 102–106. Sheep murrain is often directly triggered by weather, for example in the form of flooded pastures which can be linked to liver-fluke. Foot-rot is connected to warmth and/or humidity. Generally a lack of pastures and also hay can result in malnutrition, making the animals more susceptible to disease. On duration and effect of the sheep murrain, see Desai, Agrarian crisis in medieval England, 250–251.

information from Glastonbury Abbey and Kinsbourne in Hertfordshire which does not only indicate a very wet harvest, but also a wet and cold late winter or early spring. The failed harvest drove the grain price to unprecedented heights.

Surprisingly in 1316 the situation appears improved in the East Anglian data: the harvest was early in timing and shorter than average.[111] The data can be interpreted in the form of an average to warm growing season which was followed by a dry spell during harvest time. However, the Low Countries summer index stands only at 3, and in Saxony, Bavaria, Bohemia and Austria many inundations are recorded, those that are dated took place in the second half of June after abundant rainfalls. Timing of the inundation and geographical coverage are strong indications for a typical slow moving and rain intense Genoa Low (Vb track cyclone), which is associated with a high risk for large summer floods in central Europe.[112] A Genoa Low can not reach the British Isles and indeed the administrative sources from England lend support to the possibility that summer 1316 was unspectacular in meteorological terms.[113] The Pipe Roll of the Bishopric of Winchester, never lacking in words, does not complain about rainfall in spring and summer 1316. One manor's grievance was flooded pastures, which might also have been due to the preceding wet year 1315 and the wet winter 1315–1316,[114] and another manor referred without explanation to inadequate or inconsistent weather, but none reported actual rainfall; in any case the number of complaints is small.[115] For Kinsbourne, Stern found indi-

[111] The evidence used is from Scratby, NRO, DCN 60/30/05, Worstead, NRO, DCN 60/39/06, and Hinderclay, CUL, Bacon 446. Hallam, Rural England and Wales, 1042–1350, 1005 mentions a Sedgeford account for 1314–1315 and idem, The climate of eastern England 1250–1350, 125 cites a account from the same manor for the harvest 1316, which started on 2 August and ended on Michaelmas. Such a date would be early for Sedgeford, the harvest duration very long, but the start and end date could also indicate a standardisation of the harvest season. However, it was not possible to locate these account rolls. The NRO catalogues and the Manorial Documents Register of the National Archives list no Sedgeford account for 1314–1315 and only a tithe account for 1316, NRO, LEST/IB 79, which does not give any information on harvest date or length. In Hallam, The climate of eastern England 1250–1350, Tab. 2 on harvest date and size, the year 1316 is not given either.

[112] Messmer et al., Climatology of Vb-cyclones, 542.

[113] English narrative sources do refer to the period between c. May and September as very rainy, but it is not clear if their dating is correct, or if they do not double the events of 1315, Britton, Meteorological chronology, 70.

[114] At Waltham St Lawrence pastures were partly flooded and partly suffered from 'nimiam habundanciam aque', Titow, Evidence of weather, 387. However, Waltham St Lawrence was prone to flooding and experienced flooded pastures in many winters, see Titow, Le climat à travers les rôles de comptabilité. Titow therefore only used the references to severe flooding, when published in the weather references 1350–1450, ibid.

[115] In 1315 17 references for c. May to July are available from the manors of the Bishopric of Winchester, they come from 18 manors; every single reference mentions rainfall and/or flooding. In 1316 there are four references for the time c. May to end of June, none of them explicitly states rainfall; the information was produced by three manors. The different levels of severity of the weather conditions in 1315 and 1316 are obvious. The roll of 1315–1316 ends 29 June 1316, because bishop Henry Woodlock de Merewell died 28 or 29 June 1316. The next roll, 1316–1317, includes the quarter of the year between end of June 1316 and late September 1316, without bringing more weather references for this period, Beveridge, The Winchester rolls and their dating, 97, 112.

cations for wet conditions in late spring, but also for a dry summer. All these factors support the evidence from Norfolk and Suffolk, which points to 1316 itself being – after a wet spring – a year, that saw no exceptionally bad weather conditions during the grain growing season in England.

The data for 1316 from Norfolk, Suffolk, Hertfordshire and the Winchester manors indicate that the bad harvest in 1316 and the consequent high prices 1316–1317[116] were not solely due to the weather in 1316, but also to other factors,[117] such as the likely low quantity and poor quality of the seed corn[118] and the rainfall during winter sowing in 1315 and also at spring sowing 1316.[119] In 1316 Norwich Cathedral Priory was short of wheat, but not of barley, which confirms the problems at winter sowing time 1315 and in winter 1315–1316, whereas the spring conditions in East Anglia must not have been too contrary to barley growing.[120] A lack of seed corn might have led to less densely sown crops or a reduction in sown acreage, which was indeed taking place on many Norwich Cathedral Priory manors between 1313/1314 and 1318 (for Sedgeford and Gnatingdon, see Fig. 2.3).[121] On a national level the harvest size in 1315 and 1316 was pitifully small.[122]

However, with respect to East Anglia the reconstructed temperature and the harvest length for 1316 lend support to Hallam's theory that the Great Famine was a

[116] On harvest size again: Campbell, Nature as historical protagonist, 288. On the returns of the different grain crops on the Winchester estates 1315–1316, see the summary of Kershaw, The Great Famine and Agrarian crisis in England, 98–101.

[117] For a general assessment of the vulnerability of the various grain crops to weather, during the time between sowing to harvesting, but also during the preceding year producing the seed, see Hooker, Weather and crops, 120–121.

[118] For a detailed description of the impact a very wet summer has on the growing grain, see Pfister, Agrarkonjunktur und Witterungsverlauf, 117–118 who cites eye-witness accounts of the wet summer 1758 in the region of Bern, Switzerland. Although being temporally and geographically distant, the detailed impacts are probably comparable to those in England 1315 and perhaps already 1314. In the Bern region 1758 the corn partly sprouted in the fields, partly the kernels split open, and harvesting was extremely difficult. Fermentation set in; the grain could hardly be used to produce edible bread. It can not be assumed that such grain makes good seed corn.

[119] At least the winter sowing 1315 was very wet and pastures were flooded in winter 1315–1316, Titow, Evidence of weather, 386.

[120] Hallam, The climate of eastern England 1250–1350, 126.

[121] In Eaton, Gnatingdon, Hemsby, Hindringham, Monks' Grange, Sedgeford and Taverham. The average reduction was c.11%. The largest reductions occurred just outside Norwich, perhaps because of a greater lack of seed corn so close to the town. In Eaton the sown acreage was reduced by 15.5%, in Monks' Grange by 22.5%. Scratby is not part of this development, no downsizing took place there between 1302, the last available account before the Great Famine, and 1315. The reductions occurring on the Norwich Cathedral Priory manors are minor compared to what happened on the Christ Church Canterbury manor Appledore. The drop in Appledore between 1314 and 1316 stands at 30.3%, CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386. There might also be a connection between soil type and reduced sown acreages; in the continuous rainfall heavy soils must have suffered worse than light and well draining soils.

[122] The wheat yields on the manors belonging to the Bishopric of Winchester were down by 36% in 1315 and 45% in 1316, Titow, Evidence of weather, 285–286; barley and oats often did not fare well either, idem, Winchester yields, App. C (49), D (59), E (69). On the national demesne harvest, see Campbell, Nature as historical protagonist, 288.

difficult, but not disastrous period.[123] Although documentation of the famine years is poor, it appears that, on a more local level, the Breckland also escaped the worst in those years.[124] Slavin used the few accounts rolls of Norwich Cathedral Priory surviving for the crisis years to reconstruct harvest sizes for Eaton 1315 and Sedgeford 1316.[125] Whereas the Eaton harvest 1315 was extremely poor for all crops and especially for wheat, the data used for Sedgeford 1316 show severely depressed yields only for wheat and beans, but rye, barley, oats and to a lesser degree also peas, rendered a normal harvest quantity.[126] These results lend credence to the assumption that the 1316 barley harvest was good enough to avoid disaster in Norfolk. All evidence from the English narrative as well as administrative documentary sources, the East Anglian growing season temperature as well as harvest length, and the Eaton harvest, show 1315 as a catastrophic year, when extremely bad weather ruined all farming efforts. The summer half year 1316 still saw phases of bad weather, but did not undermine farming entirely and allowed for good harvests of rain resistant crops, at least on manors on sandy soil. The only major grain crop that failed in Sedgeford 1316 was wheat, which was still sown during the deluge 1315 and which is a rain sensitive crop. Therefore it is likely that Norfolk's (including the Breckland) well draining soils and its reliance on the hardy barley reduced the vulnerability of this region to continuous rainfall and flooding, and avoided a general second harvest failure in 1316.

Even though Norfolk escaped the worst, socio-economic impacts of the Great Famine were severe. In the fourteenth century, during periods of raised grain prices, the level of crime fluctuated with the price of wheat. Hence in the famine period 1315–1317 crimes in Norfolk rose by 382% above the pre-famine level, these crimes included also an increased percentage of stolen foodstuffs.[127] At the same time the land market was very active, bearing witness to the difficulties of the peasants. At Hindolveston the surrender of property by tenants rose by 160% in 1316 compared to the preceding year and in 1317 the number of transactions was still 70% above the level of 1315. These surrenders were made for 'great hunger'.[128]

In 1317 the East Anglian data default; other manorial accounts hold no evidence on high rainfall levels that can be attributed to the growing season and harvest 1317.

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[123] Hallam, The climate of eastern England 1250–1350, 126, 132, see ibid., 129 on sizes of the Norfolk barley harvests 1258–1349.

[124] Bailey, A marginal economy, 201–202.

[125] Sedgeford, tithe account, NRO, LEST/IB 79. Slavin, Feeding the brethren, 130, points out, that the computations based on the tithe roll are less reliable than those based on the normal manorial accounts.

[126] Slavin, Feeding the brethren, 129–131. Average harvest calculated on the basis of 'normal' harvests between 1311–1312 and 1318–1319. Sedgeford lies on the 'Good Sands' (note 3 in Chap. 5), and well draining soils are of advantage in years of dramatically increased precipitation levels. Eaton's soils tend to slight seasonal waterlogging, Soils of England and Wales: Sheet 4 Eastern England. The manorial accounts of 1315–1316 allow no assessment of the quality of the grain harvested.

[127] Hanawalt, Crime in East Anglia, 14.

[128] Hallam, The climate of eastern England 1250–1350, 126, Fagan, Little Ice Age, 39.

The summer half year in the Low Countries was average. Conditions appear to have approached normality; the harvest definitely was better than in the preceding years, bringing down the grain prices by 50%.[129]

In England the dearth found an end in the good harvest after the very warm and dry growing season 1318. In this year the harvest in East Anglia was generally very early and shorter than average, conditions were similar further west in Staffordshire and in the south on the Winchester manors.[130] In the Winchester Pipe Roll drought references are also frequent. Around Norwich the soil was so hard that it caused problems for fallow ploughing (Appendix 1). As a result of the dry and warm weather the barley harvest in Norfolk was poor,[131] but England-wide the grain harvest was good and prices fell to a very low level after the harvest. The English weather conditions were mirrored on the other side of the sea, where the summer half year index is 7.

Lucas considered 1318 as the end of the famine, whereas Kershaw extends the phase of agrarian crisis to include the years up to 1322 on the basis of the cattle plague 1319–1321 and renewed harvest failure in 1321.[132] In fact Jordan speaks of the Great Famine 1315–1322, which implies seven consecutive harvest failures, which in England was certainly not the case and for which – as we have seen – weather conditions as a basis for such a continuous failure were non-existent.

It is worth outlining the prevalent weather modes of the growing seasons in question. The year 1319 can be classified as rainy and cold again. The reconstructed East Anglian April to July temperature is low. The manorial accounts of the Bishopric of Winchester contain isolated references to rain in the growing season and a wealth of references to rain at harvest time, which is reflected by the longer than average harvest in East Anglia.[133] The barley harvest in Norfolk was, however, normal,[134] as was

[129] Kershaw, The Great Famine and Agrarian crisis in England, 95.

[130] Lynam (ed.), Croxden Chronicle, vii.

[131] Hallam, The climate of eastern England 1250–1350, 129. In the Breckland agricultural output was also reduced, Bailey, A marginal economy?, 201. Neither the poor Norfolk barley harvest nor the bad general grain harvest in the Breckland are surprising. The Breckland soils are very drought sensitive, and barley is vulnerable to prolonged dry conditions.

[132] Kershaw, The Great Famine and Agrarian crisis in England, 96.

[133] Hallam, The climate of eastern England 1250–1350, 126 and 128, claims, that narrative sources describe a summer drought, that preceded the wet autumn in 1319, without giving the sources. However, those references could not be found. Britton, Meteorological chronology, has nothing for 1319, Ogilvie gives no drought index in 1319, the Pipe Rolls of the Bishopric of Winchester mention no dry weather, Stern identifies nothing in the Kinsbourne (Hertfordshire) accounts hinting at drought, Bickersteth cites no drought evidence in the manorial accounts of Christ Church Canterbury. However, the reconstructed Norfolk growing season mean temperature is low, which makes prolonged dry conditions in the summer half year rather unlikely. No Dutch summer season index is available.

[134] Hallam, The climate of eastern England 1250–1350, 129. Considering Hooker's statement that barley likes a cool growing season between May and August and the temperatures in East Anglia are often too high for optimum conditions, the normal barley harvest 1319 does not come as a surprise, Hooker, Weather and crops, 121.

the English grain harvest in general.[135] As long as the narrative sources have not misdated the Great Famine, they remain silent for 1319.[136] The real calamity befalling England in this year was the cattle plague, arriving around Easter in Essex.[137] As Slavin points out, the frequent lack of pasture, hay and fodder in the preceding years will have raised the vulnerability of the cattle.[138] Due to the cattle plague the average English demesne cattle stock shrank by 63%.[139] While Desai sets the period for restocking somewhat optimistically to roughly 10 years,[140] Slavin found that oxen numbers reached c.80% of the pre-plague levels by 1331 and dairy cattle c.90% by 1341.[141] Whereas the effects of famines were relatively quickly overcome for the survivors, the rebuilding of cattle herds needed decades. The epizootic impacted on the agricultural sector by the loss of draught animals and manure, and on human diet directly via a severe drop in dairy and meat consumption.[142]

According to the Norwich Cathedral Priory harvest data the weather situation improved in 1320, the reconstructed April to July temperature was average, but the harvest duration was above average. The latter is easily explained: once more it was a rainy harvest and the Winchester manors experienced problems, too. The manorial accounts remain silent in respect to the months between early spring and harvest, which implies average conditions. The East Anglian harvest date complies with this. Neither for 1319 nor for 1320 are enough data available in the Low Countries to permit indexing the summer half year. Whereas Kershaw saw indications that the harvest 1320 was merely mediocre and therefore the grain price 1320–1321 was higher than in the previous year, Campbell's comparatively recently collected data from the demesne farming sector shows average yields.[143]

Then in 1321 harvest failure returned and England was part of a zone of poor harvests stretching from the British Isles, probably over northern France, and then from central Europe to northern Italy. On the island the grain prices again approached the levels of 1315–1317.[144] The chronicles in England do not refer to adverse weather conditions during the growing season, making Kershaw suspect a drought instead of the more striking rainfall as cause of the English harvest failure.[145] During

[135] Campbell, Nature as historical protagonist, 288.

[136] Kershaw, The Great Famine and Agrarian crisis in England, 88.

[137] Slavin, Cattle plague, 166.

[138] Ibid., 167.

[139] Ibid., 168.

[140] Desai, Agrarian crisis in medieval England, 257.

[141] Slavin, Cattle plague, 177.

[142] Ibid., 169–171.

[143] Kershaw, The Great Famine and Agrarian crisis in England, 97, Campbell, Nature as historical protagonist, 288.

[144] Alexandre, Le climat en Europe, 442–443, Campbell, Nature as historical protagonist, 288, Kershaw, The Great Famine and Agrarian crisis in England, 97.

[145] Ibid., 97. The Brut, 223, mentions snowballs in connection to the execution of Thomas of Lancaster on the 22 March at Pontefract Castle under the 1321. This would indicate a long hard winter 1320–1321, however, the Brut misdates the events, Thomas of Lancaster died in 1322.

the political upheaval in England in that year, a silent drought might not have commanded the chroniclers' attention. Indeed, apart from very few references to dry conditions sometime between May and June the Winchester estates also do not supply any weather information for 1321, but the given references are not sufficient for suspecting much more than a dry spell. The Kinsbourne accounts indicate wet weather at winter sowing time in 1320 and then again flooding in spring 1321, both would impede upon sowing and lower the chances of harvest success. In East Anglia the growing season temperature was slightly above average and would allow for a period of warmth and possibly dry conditions in spring and early summer, but the summer index for the Low Countries is slightly below average in 1321, at 4. The East Anglian harvest length was average in 1321. None of these references and proxies indicate a really severe drought that could have destroyed the grain crops. Looking across the Channel reveals a wet summer period in northern France, where in the Paris region processions took place in August to stop the rains, which were damaging the crops. The year counted as wet in central Germany. Hail and rain played a role in the harvest failures in Germany, in Italy they were due to rainfall setting in during late July. The rain affecting northern France in August might have reached into England, but no references to it survive. Tree-ring data from England point indeed to rainfall levels above average, but they were by no means excessive.[146] The evidence assembled points to the harvest failure 1321 being due to a combination of factors: wet seed corn from the harvest 1320, probably raised rainfall levels at winter sowing time 1320, increased wetness levels in spring 1321 followed by drier conditions and possibly rainy weather at harvest. This resembles strongly one of the weather patterns that forebode badly for the grain harvest according to Titow,[147] but still cannot fully explain the exploding grain price.

The harvest was average in 1322[148] and after the harvest the grain price began to fall, but corn stayed expensive until the mid-1320s. Not much contemporary evidence is available from England, also no manorial accounts of the Norwich Cathedral Priory estates survive for 1321–1322.[149] In Hertfordshire late winter and early spring were very cold; in late March the ground appears to have been still covered by snow at Pontefract Castle in northern England.[150] Conditions in northern France were similar, the frost lasted until mid-March, the snowcover even longer.[151] In addition to the extremely long harvest in East Anglia, information from Hertfordshire also indicates a wet late summer and autumn period. Bad weather also

[146] Alexandre, Le climat en Europe, 442–443. For the tree rings see Cooper et al., Hydroclimate variability.

[147] A wet autumn followed by an unremarkable and probably average winter and a dry growing season, Titow, Evidence of weather 363.

[148] Campbell, Nature as historical protagonist, 288.

[149] The accounts of the Bishopric of Winchester also default, the see was void, see Beveridge, The Winchester rolls and their dating, 98.

[150] When on the way to his execution snowballs where thrown at Thomas of Lancaster on 22 March 1322 at Pontefract Castle, Brut, 223 (in the Brut erroneously under 1321).

[151] Alexandre, Le climat en Europe, 443–444.

characterizes the summer half year in the Low Countries which was cool (3), in some areas inundations due to snowmelt lasted until May and new floods occurred in late June.[152]

The meteorological conditions of 1323 are obscure. The winter 1322–1323 was extremely cold. In Hertfordshire parts of spring seem to have been wet. For the summer half year the documentary sources in the Low Countries supply insufficient data to set an index. However, indications are that spring and summer were not ideal for grain cultivation. The winter 1322–1323 was probably not only very cold, but also long, thereby delaying the onset of the growing season, which in East Anglia started out wet and could never make up for the late start; April–July mean temperatures were low. In late June a tornado and a water spout did significant damage in the surroundings of Leeds.[153] Such phenomena arise, when advancing cold fronts meet warmer and wet air masses over the British Isles in summer. The Norfolk barley harvest was good,[154] as was the grain harvest on a national level,[155] but the grain price, even though sinking, remained high after the harvest 1323. The 1323 growing season was the last marked by a low mean temperature and probably at least spells of wet weather. With this year ends the cycle of recurrent cold and wet years between 1314 and 1323.

The analysis of the years 1320–1323 reveals a period when the rising or high grain prices seem to be strangely detached from the weather events (only 1322 saw clearly a wet growing season) and also from the harvest success of the demesne farming sector, which normally was a strong predictor for the grain price.[156] The Great Famine 1315–1317 and its effects generally stand in the centre of attention of studies dealing with the agricultural and pastoral upheaval 1314–1323, hence it is advisable to focus here on the cause and the socio-economic consequences of the price spike in the early 1320s. Campbell's data on the agricultural and pastoral sectors of demesne farming and Slavin's data on the cattle plague inform the following analysis. In 1320, 1322 and 1323 harvests were average or good, but the grain price first was rising and later not returning quickly to normal after the spike caused by the 1321 harvest failure. Part of this discrepancy can be explained with the harvests being wet in 1320, 1322 and possibly in 1321, and wet harvests are voluminous and heavy, while the quality of the grain is actually lower than that of grain gathered in under dry conditions.

However, the rapid succession of the cattle plague and the period of high grain prices suggests that the massive mortality amongst the cattle impacted on the grain

[152] Ibid., 444.

[153] Flores Historiarum, vol. 3, 216–217.

[154] Hallam, The climate of eastern England 1250–1350, 129.

[155] Campbell, Nature as historical protagonist, 288. In Cuxham, Oxfordshire, the barley harvest was normal whereas the wheat harvest was very poor, Hallam, The climate of eastern England 1250–1350, 131, based on the data from Harvey (ed.), Manorial records of Cuxham. The poor wheat harvest might be due to a wet growing season, but also to rainy weather at sowing time as indicated by, Stern, A Hertfordshire demesne, 94, who states that the wheat seed was damp when sown in autumn 1322. Wet seed corn is detrimental to the success of wheat cultivation, Hooker, Weather and crops, 120.

[156] Campbell, Nature as historical protagonist, 297.

Fig. 6.1 Ploughing with oxen. Luttrell Psalter, Lincolnshire, circa 1325–1340 (British Library, Add. MS 42130, f. 170)

production and price. In its immediate aftermath the catastrophe in the pastoral sector raised the vulnerability of the agricultural sector to the vagaries of the weather. The loss of draught animals posed a problem to the time-intensive ploughing (Fig. 6.1). A reduction of manure reduced the available amount of fertiliser. The transport costs for grain must have increased, which in turn would be reflected in the grain price.[157] Regions where horses were already well in use as draught animals, as in Norfolk, were suffering less from the cattle plague, as were the peasantry who were quicker than the demesne sector at adopting the horse as draught animal. However, possibly due to stocking densities and transport links, the mortality of cattle was higher further west and south, where the use of oxen was still predominant.[158]

The spread of the cattle plague shows the sequence in which regions dropped into a state of acute shortage of draught power. After its arrival in Essex at Easter 1319 the murrain joined the supply trains for the war with Scotland and by August 1319 had travelled to northern England, in late summer it had spread across East Anglia, but its spread westwards was slower and Wales was reached around September 1320.[159] Therefore winter ploughing 1319 was primarily affected in the east, where horses were the dominant draught animal, spring ploughing 1320 was under threat everywhere. The cultivated acreage contracted for the harvest 1320, which was average on the acres that could be sown, thus explaining the different evaluation of that harvest by Kershaw and Campbell. For the harvest 1321 part of winter ploughing may still have been pulled through at some places in the west, but by spring ploughing time, the murrain had run its course. In this context, it is of interest that the grains failing worst in 1321 were the spring grains barley and oats, not the winter grains wheat and rye.[160] However, barley and oats are also more

[157] Ibid., 289.

[158] On the geographical distribution and the reasons for the varying mortality levels, see Slavin, Cattle plague, 168–169. For the use of oxen and horse as draught animals across England, see Langdon, Was England a technological backwater, 282–283, idem, Economics of horses and oxen, 40.

[159] Slavin, Cattle plague, 166.

[160] Campbell, Nature as historical protagonist, 288.

drought sensitive than the winter corn. When analysing the reasons for harvest failure and dearth Merle in 'De pronosticacione aeris' – even though the text focuses mainly on meteorological parameters – names the lack of ploughing or the wrongly timed ploughing as the first cause of harvest failure; without him specifying his motif, it appears as if the short and long-term effects of the cattle plague were still at the forefront of his mind 20 years after the cattle plague.[161]

Keeping the shortage of draught animals in mind, that what normally would have been simply bad weather with associated problems at the ploughing times in the early 1320s, now became an existential threat. Winter and spring ploughing were repeatedly disrupted by rainy weather or cold and long winters. It was raining in autumn 1320 and in spring 1321 there was flooding, this would have slowed down the ploughing work further. The winters 1321–1322 and 1322–1323 were both hard and long, scoring 7 and 8 in the Low Countries, and in 1322 spring ploughing was delayed by weeks. When speed was crucial there was a dramatic lack of draught power to compensate for the late start of the ploughing season, and tilling the land with spades is a slow, work intensive process, which can never make up for a lack of plough-animals. Harvests on the ploughed land were still acceptable, but the cultivated acreage declined sharply. Even on the estates of the Bishopric of Winchester arable acres were halved between 1319 and 1321.[162] No data are available for the decrease of cultivated acres in the peasant sector of farming, but for the peasants, so shortly after the last famine and faced with renewed high grain prices, resources for maintaining their cultivated acres must have been even scarcer than those of the lords. And they kept shrinking.

Already in 1320 the Bishopric of Winchester doubled the numbers of horses on its estates.[163] The nadir of the demesne oxen numbers was reached in that year, but from 1321 onwards they increased rapidly for about a decade, while the number of other cattle remained low for about the same time.[164] This recovery of oxen numbers was clearly not achieved by reproduction, but by acquisition. Such a restocking strategy of draught animals and the necessary purchases at a time of high grain and high cattle prices could only be pursued by wealthy lords, and the only source for this replenishment of demesne ox teams was the cattle of lesser landowners and peasants. Since the cattle plague had ravaged all herds, the replenishment of the great estates was a reallocation of the scarce resource of draught power. In those times of political upheaval not all transactions were by free will or entirely legal, as the events at Croxden Abbey in Staffordshire illustrate. The monasteries neighbour at Alton (Alveton), decided to compensate his own losses by taking not only one of the abbey's wagons and 160 of its sheep, but 20 oxen and 32 horses, when they were just under plough. The abbey and the lord of Alton made peace within a few months, but as a result of the robbery, the abbey could not plough the lands at the grange and

[161] Merle, De pronosticacione aeris, BLO, MS Digby 147, fols. 136r–136v.

[162] Slavin, Cattle plague, 169.

[163] Ibid., 176.

[164] Campbell, Physical shocks, 25, Slavin, Cattle plague, 178.

another manor, whereas the lord of Alton could probably do his ploughing.[165] In general at a time when there were too few draught animals, while pasture was plentiful, it would have been reasonable to literally cling on to oxen and to profit from their ploughing and carting services, and only the spectre of hunger that was raising its head with the harvest failure 1321 could have convinced peasants and small landowners to do otherwise. As the consumption of seed corn and the sale of land, peasants putting their oxen on the market equalled the decision to sell the future productivity of their land for the survival in the present. None of these actions were a sustainable coping measure, when faced with persistently high grain prices. By 1323, in the third year of raised prices, the poorer sections of the English people had met with their limits: land sales and the crime rate shot up. The sale of land and the recourse to crime were coping mechanism that had already been employed during the Great Famine.[166] Under those circumstances it is unlikely that the peasant agriculture could compete with the performance of seigniorial agriculture during the early 1320s. The situation improved in the mid-1320s, when weather better suited for grain cultivation succeeded the volatile phase 1314–1323 and the reproduction of the bovine population yielded the first generation of adult trained oxen born after the cattle plague; grain and cattle prices fell. The catastrophe in the pastoral sector therefore raised the vulnerability in the agricultural production and during the immediate post-epizootic period the cattle murrain enhanced the stress caused by inclement weather during agricultural activities. The murrain was itself an important factor driving up the grain price in the early 1320s.

The data on harvest date and length from East Anglia add new information about the severity and phases of the climatic conditions during the Great Famine, the time of the cattle plague and the subsequent difficult years in the early 1320s. As Kershaw stated for this period in England, it ‘was not a single entity’. Nor were the climatic conditions present. They rather represent a jigsaw, containing extremely wet and cool years, as well as warm and dry years. Excessive rainfall set off a vicious sequence, causing first a wet harvest 1314 and then severe harvest failure in 1315. Since no major adverse weather is recorded in the administrative sources or mirrored in the East Anglian data for growing season and harvest time 1316, the continued harvest failure at least in this region was largely due to wet sowing times in 1315–1316 and a wet spring 1316 and to some extent also to the agricultural and socio-economic consequences of the preceding poor and wet harvests. The latter also applies to the harvest 1317 which was still 10% below average.[167] In other words it took medieval English agriculture two years to offset the cumulative impact of the sodden harvest 1314, the rain induced disaster of 1315 and the subsequent failure 1316. In England the grain prices fell to normal levels, helped by good grain growing conditions, in 1318, and high grain prices were not to return until the harvest 1321, though the harvests 1319 and 1320 were wet and in 1319 the growing

[165] Lynam (ed.), Croxden Chronicle, vii–viii; on the general lawlessness and plundering of the times, see Fryde, Edward II, 69–86, 149–152.

[166] Campbell, Nature as historical protagonist, 291–292, Hanawalt, Crime in East Anglia, 14–15.

[167] Campbell, Nature as historical protagonist, 288.

season also cool. After the fall of the grain prices to normal levels in 1318 it was less than a year left before the arrival of the cattle plague in spring 1319, which constitutes the second major factor in the agrarian crisis 1314–1323. The high mortality was linked to the long phases of malnutrition the bovine population must have suffered in the preceding years and also in the winter 1318–1319 due to flooding and the destroyed hay crop.[168] The harvest failure 1321 appears to be the result of a variety of factors such as the use of wet seed corn, wet ploughing times, a lack of draught power, and for the growing season neither a severe drought, nor heavy rainfall in summer can be ruled out. For this harvest and in the immediately following years, of which 1322 was once more wet and cold, the lack of cattle contributed to the high grain prices.

To extend the Great Famine in England from its core years 1315–1317 to cover the following cattle plague and the harvest failure 1321 or even longer[169] is confounding the term with respect to cause and outcome. There was no continuous climatic crisis in the form of those dangerous cold and extremely wet growing seasons and there was also no consecutive harvest failure for seven years. A major crisis in the agricultural sector was followed by one in the pastoral sector, both with mutual repercussions. Although the cattle plague had in the long-run more profound and severe consequences for agricultural production than the Great Famine, it did not result in the immediate death of c.10% of the population,[170] so that it could be adequately labelled 'Great Famine'. Although it created problems for agriculture, the difficult two decades for landowners after c.1325 were mainly caused by low corn prices[171] that means by good harvests.[172]

6.5 Weather Conditions During the Great Pestilence 1348–1349 and the Agricultural Crisis 1348–1352

The arrival of the Black Death in Britain and the agricultural crisis in the late 1340s followed a sequence of years with suboptimal conditions for farming. For 1345 Adam Murimuth describes a very wet harvest. It was raining throughout August and in some regions corn perished in the wet weather and could not be stored dry.[173] This continuous rainfall affected the west of England, where the manors of the Bishopric of Winchester and of Glastonbury Abbey complained about rainfall, but further east conditions were probably less severe as in Sussex the season counts as unremarkable and in East Anglia the harvest was longer than average, but not very long.

[168] Titow, Evidence of weather, 387.

[169] Slavin, Cattle plague, 179 extends it to 'at least until the 1330s and beyond.'

[170] Kershaw, The Great Famine and Agrarian crisis in England, 93.

[171] Desai, Agrarian crisis in medieval England, 253.

[172] Campbell, Physical shocks, 28.

[173] Murimuth, Continuatio Chronicarum, 173.

However, as is indicated by Murimuth[174] the rainfall persisted well into autumn and until the sowing time of the winter corn, as evidence from Hertfordshire and the Winchester and Glastonbury manors also shows. Flooding took place in winter. High levels of rainfall during sowing time are detrimental to crop growth, as is poor quality seed corn from a wet harvest, and in consequence of these conditions wheat and rye suffered. The harvest 1346 was not sufficient to avoid a price rise and dearth took hold in England about a month before the harvest 1347.[175]

With 1347 the temperature of the summer season began to drop towards the extremely cold summer of 1348. The growing season opened with dry weather as the manorial accounts from Hertfordshire, Sussex and Surrey attest. The conditions were so severe as to result in suffering from heat, a lack of fresh water and dysentery for the English besieging Calais.[176] By harvest time the character of the season had changed and rainfall had set in on the Winchester manors and in Sussex. Reflecting the cool-wet second half of summer the Low Countries index stands at 4. In East Anglia the harvest was short, showing drier conditions in this region but also demonstrating the resolution to finish harvesting before the end of the official harvesting season in late September. Nonetheless the grain crops, including the sturdy barley, responded badly to such weather, and the grain price did not sink in the year 1347–1348.

While the Black Death was spreading north from the European Mediterranean coast across the continent, the poor in England must have been facing difficulties in securing their daily bread, and indeed the weather in 1348, the year the epidemic crossed the Channel, would increase the pressure on grain cultivation. Apart from being more likely to rot, grain grown and stored in wet conditions is nutritionally inferior and more liable to infection with fungi. In short, many English must have encountered the newly arrived epidemic in a malnourished and immunodepressed state.

In 1348 the April to July average temperature was low (Fig. 5.4), the summer in the Low Countries was average. The year is also known to have been wet, at least from Midsummer onwards, in English chronicles references to continuous rainfall from about the Nativity of St John the Baptist (24 June) to Christmas are plentiful.[177] John of Reading gives one of the accounts written closest to the actual event.

> [Anno gratiae MCCCXLVIII] Eodem anno, circa partes meridianas occidentalesque inundaverunt pluviae a Nativitate Sancti Johannis Baptistae usque ad Nativitatem Domini, vix diebus vel noctibus cessantes quin plueret aliquantulum.[178]

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[174] Ibid.

[175] Knighton, Chronicon, vol. 2, 88–89.

[176] Ibid., 86–87.

[177] For a list see, Britton, Meteorological chronology, 141. To his list can be added various London chronicles, which tend to misdate the event by one or two years.

[178] Reading, Chronica, 106. In a note the editor adds, that the reference bears a close similarity to a passage in Higden, Polychronicon, vol. 8, 347. The remark about the rain falling in the west and south, though, is unique to John of Reading and found nowhere else.

The high levels of precipitation are explicitly localized in southern and western England, and rainfall impacts were indeed recorded for Sussex and the Winchester manors, whereas in East Anglia the harvest duration was shorter than average and the Hertfordshire manors of Westminster Abbey did not report any rainfall impacts in 1348, as they do then in the following year 1349.

In 1349 when the Black Death raged in England, the weather remained very wet, in fact the rainfall might have been more severe than in 1348. The harvest was wet in Hertfordshire and on the manors of Glastonbury Abbey; the Winchester accounts for winter, late summer and harvest mention many problems caused by floods and rain. The harvest in East Anglia was long, though it is not clear if this was due to the rain or to the lack of labour during the epidemic.[179] In Taverham oats perished on the fields,[180] this might have been the effect of an unmentioned dry period in summer, or – since oats are not likely to suffer much from rainfall – it might also been a result of a lack of harvesters as the villagers fell victim to the plague or survivors demanded higher wages. In England unharvested fields were common in 1349.[181] Nonetheless the Norfolk barley harvests defied the weather conditions as well as the lack of labour and were normal or good in 1348 and 1349,[182] Henry Knighton also describes the corn as abundant.[183] However, the national English grain harvest fared considerably less well.[184] Major price rises were only avoided because of the great mortality which led to a sudden breakdown on the demand side.[185]

Another very bad harvest followed immediately in 1350, indeed in the seigniorial sector of English agriculture seed-yield ratios remained far below the long term average until 1357 and were even 40% below average for the years 1349–1352.[186] The difficulties in maintaining agricultural output are observed in the Polychronicon which complains about the land and sea in post-plague years being more barren than before.[187] Traditionally these harvest failures were attributed to the disruption of agricultural activities and the demographic downturn. Campbell widens this view and emphasizes the role of unfavourable environmental conditions which was also indicated in the Polychronicon.[188] As indicators he uses tree growth data, which slumped in the late 1340s, and information about temperature over western

[179] The harvest duration 1349 and 1350 on most Norfolk manors was actually exorbitantly long; which is a clear sign for a greatly diminished labour supply for (demesne) farming. Such data were excluded from the statistical analysis.

[180] NRO, DCN 60/35/30 for 1349–1350, but referring to 1349. For the difficult farming year 1349 almost no Norwich Cathedral Priory accounts survive.

[181] Knighton, Chronicon, vol. 2, 100–101.

[182] Hallam, The climate of eastern England 1250–1350, 129.

[183] Knighton, Chronicon, vol. 2, 100–101.

[184] Campbell, Nature as historical protagonist, 301; Dodds, Estimating arable output, 270.

[185] Hatcher, Plague, 21–25. Concerning the disruption of the grain market and the price system during plague years, see Campbell, Nature as historical protagonist, 304.

[186] Campbell, Nature as historical protagonist, 301.

[187] Higden, Polychronicon, vol. 8, 347.

[188] Campbell, Physical shocks, 20–24, idem, Nature as historical protagonist, 300–305.

Greenland, which shows a period of intense cold 1349–1353.[189] However, since the excursions of cold air over Greenland extended until 1353, this implies that bad weather played also an important role in the harvest failures in 1350, 1351 and 1352.

Yet evidence of prolonged rainy and cold conditions is scarce for these years. In Sussex the year 1350 appears normal, in the Winchester area a few pastures or meadows were flooded during winter or summer and in Hertfordshire there is evidence not only for a wet spring, but also for a dry summer, followed by fine weather in autumn. In the Low Countries the summer was warm and fine, rain affected farming in August.[190] The East Anglian growing season and the summer half year in the Low Countries were average to cool,[191] the latter is indexed 4. The bad harvest 1350 and the subsequent price rise for grains was partly still due to the social upheaval in the wake of the Great Pestilence[192] and partly to the seed corn stemming from the two wet and bad harvests of the preceding years, the wet spring and possibly a wet harvest time; but rainfall levels were not comparable to those in 1348 and 1349.

The grain growing season of 1351 is more difficult to assess. Again no references to weather events interfering with agriculture could be found in Sussex, and whereas the Westminster Abbey manors in Hertfordshire experienced difficulties in winter and then a wet spring, no references to summer exist, and October and November saw fine weather. The spring might have been wet in south-central England too, there the Winchester manors repeatedly reported flooding in winter and summer. The summer flooding seems to centre around hay harvest time, since hay making was interrupted, the hay was partly ruined or even carried away by the water. For southeastern England very dry growing season conditions are assumed.[193] At least from May onwards it was warm in the Low Countries, the vegetation was advanced, the grain harvest is said to have suffered from the heat. After August it was rainy.[194] The East Anglian April–July mean temperature and harvest duration were average. In fact in the years immediately following the Great Pestilence an average harvest length is, considering the labour reorganisation, comparatively short and could well indicate dry conditions (Sect. 7.1). The Low Countries summer stands at 6 and more continental Europe, France and Germany, witnessed a hot and dry summer *par excellence*, so hot and dry indeed, that here too the grain was damaged.[195] The meteorological character of the growing seasons in 1350 and 1351 is therefore very dif-

[189] Dawson et al., Greenland (GISP2) ice core, 431.

[190] Alexandre, Le climat en Europe, 478.

[191] Most harvests in East Anglia were excessively long 1350, possibly that was not only due to the social upheaval, but also to rainfall in August 1350. However, there is no English direct evidence for the rainfall of the Low Countries stretching indeed into England in August 1350.

[192] For example on Breckland manors in 1349 boon services were not performed and labour had to be hired, disrupting demesne farming, Bailey, A marginal economy?, 224. 770 out of 890 works owed by the tenants to the lord at Fornham were still not rendered in 1352–1353.

[193] Classic drought impacts are cited by Mate, Agrarian economy after the Black Death, 342–343.

[194] Alexandre, Le climat en Europe, 479.

[195] Le Roy Ladurie, Histoire humaine et comparée du climat, 68–70.

ferent from the preceding two years. The weather was less likely to have caused massive harvest failure by itself in England, although in 1351 an unpleasant spring and then drought in parts of summer probably played a role. In any case prices continued to rise further.

In 1352 then conditions are totally reversed compared to the years 1348–1349. The reconstructed growing season temperature in East Anglia is average to warm, and in the Low Countries the summer was similar (7). It was a very dry spring and early summer. The account rolls of the manors of the Bishopric of Winchester abound with references to drought and even report heat. Some of the manors attributed their problems with the growing of spring corn, which is drought sensitive, to the lack of rain. Barley and oats harvests were actually only at about half their normal yield. Drought information also comes from the manors of Christ Church Canterbury.[196] After the dry weather and the damage to the spring corn, rain fell in summer in Sussex, in East Anglia the harvest duration was average in the context of the whole series, so it might again indicate dry conditions in these chaotic post-plague times. In the Low Countries the summer was hot and dry, the drought was severe and greatly reduced the quantity of the hay, fruit, legume and oat harvests; however, under the warm conditions the wheat harvest was good and the wine of good quality.[197] These weather conditions extended further into continental Europe.[198] Some narrative English sources report a major drought in 1352, others in 1353. Henry Knighton describes under 1352, how in the extreme drought the cattle perished from a lack of water on the pastures and the marshes dried up, so that new pathways appeared.[199] John of Reading refers to the damage done by the dry weather from March to July 1353 to the corn and hay and mentions even relief efforts in the form of grain shipments from Zeeland to help the Londoners.

> [Anno gratiae MCCC quinquagesimo iij] Provenit et hoc anno tanta siccitas a mense Martii usque ad Julii mensem, quod non cecidit pluvia super terram, unde fructifera, seminata et herbae pro majori parte perierunt. Ob quorum defectum sequebatur magna miseria hominum et / jumentorum caristiaque victualium, adeo quod Anglia semper fertilis ab insulanis indiguit quaerere victui necessaria. Quorum misertus egestatis dux Willelmus de Selond plures naves onustas siligine Londonias direxit.[200]

Although in 1353 spring was very dry in Sussex, Hertfordshire, and probably also in Norfolk (Appendix 1), and these conditions reached into the Low Countries, the abovementioned drought descriptions in English chronicles refer rather to 1352, when the drought was most severe in the lands across the North Sea and also in England according to the administrative accounts.[201] Although the oat harvest was lost in some

[196] CRU, Bickersteth, Minister's account rolls of Christ Church Canterbury 1305–1386, Mate, Agrarian economy after the Black Death, 343.

[197] Alexandre, Le climat en Europe, 480.

[198] Le Roy Ladurie, Histoire humaine et comparée du climat, 72.

[199] Knighton, Chronicon, vol. 2, 118–119.

[200] Reading, Chronica, 117–118.

[201] For a list of the sources describing the drought, and on the subject of misdating this event, see Reading, Chronica, 117–118. The editor of the Chronica assumes that Reading's drought para-

places in Sussex, the general grain harvest in 1353 can not have failed, since the grain price was low over the following months. The temperature indicators point to an unspectacular year: the growing season temperature in East Anglia was average to warm, in the Low Countries the summer was average. The climatic factor causing the bad harvests in 1352 and potentially also 1353 was drought, and the socio-economic impact of the post-plague labour shortage as well as a reduction in the sown acreage (for Sedgeford-Gnatingdon see Fig. 2.3) must still have played a role.

Even though the agricultural crisis around the time of the arrival of the Black Death came to an end in the early 1350s, severe climatic conditions returned in the mid-1350s. The harsh and strangely contrary weather of 1356 is worth describing: spring and early summer were marked by severe drought, and from the end of June this was followed by a very rainy summer. In Sussex the year was dry. Robert of Avesbury and the manors in the hand of the Bishop of Winchester give an impressive list of drought impacts, before the latter embark on the problems of a rainy and long harvest. According to Avesbury the drought started in March and was ended by rainfall beginning around midsummer. The rain invigorated the withered crops.

> […] a medietate mensis Marcii usque festum Nativitatis sancti Johannis baptistae, […] valde modicum pluit, sed tanta fuit siccitas quod ordea, avenae, vescae, fabae, et alia semina quadragesimalia in multis locis Angliae modicum vel nihil crescebant. Post dictum vero festum sancti Johannis baptistae pluit in magna abundantia; et dicta semina, ordea, avenae, vescae, et fabae incipiebant crescere et fuerunt satis alta et spissa, et tamen edgrowe.[202]

One Winchester manor harvested until All Saints Day, 1 November (Gregorian Calendar: 9 November). This extraordinary duration and also the longer than average harvest in East Anglia can partly be attributed to the renewed crop growth after the end of June. Therefore the climatic conditions 1348–1353 in England can be classified as highly variable. In 1348, 1349, 1352 and possibly 1353 the weather, though first in the form of relentless rainfall and cold, and then in the form of excessive drought and heat, impacted greatly on the harvest success. In 1351 conditions were very variable, spring appears as very wet and summer as dry. Indications are that the crop failure 1350 was not so much the result of extreme weather during the growing season (August 1350 may have been wet in England as it was in the Low Countries), but was rather caused by the dearth and rain impacts in the preceding years (lack of seed corn, wet seed corn), and by the societal disruption in the wake of the Black Death. Quantifying the climatic and the demographic influence is impossible.

Considering the variable climatic conditions during spring and summer over England and the Low Countries for 1348–1353 the connection of the English harvest success to the low temperatures over western Greenland is unclear. The use of cold air excursions over Greenland and the associated North Atlantic sea-surface temperature proxy record as predictors for summer rainfall in Europe[203] is problem-

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graph is referring to 1352 and his description of the withering fruit, seeds and grass indeed echoes the drought impacts in the Low Countries in that year, where fruit, hay and grass also suffered.

[202] Avesbury, De Gestis Mirabilibus, 468. ‘Edgrowe’ is the ‘aftermath’ according to the editor.

[203] Dawson et al., Greenland (GISP2) ice core, 430–433.

atic, the signal of annual or winter meteorological conditions in Europe contained within the North Atlantic sea-surface temperatures is not a good indicator of the European summer rainfall pattern.[204]

The wet and cool summer seasons of the late 1340s and the consequent harvest failures, could well have, as Campbell has stated, led to another Great Famine, if it were not for the Great Pestilence wiping out about one third of the population of England.[205] As things stood, the bad and wet harvests raised the vulnerability of the people to disease. Considering the demographic catastrophe and the climatic extremes, it is clear that in 1348–1353 all certainties and securities were obliterated, even the weather was entirely unpredictable, the experience and resources to cope with it were reduced, and the general character of these years appears as merciless.

6.6 Summary of Extremely Warm and Cold Growing Seasons

Complementing extreme reconstructed mean temperatures April–July with independent documentary evidence permits a fuller picture to be formed of the extreme years. Cold and wet growing seasons attracted much attention by the chroniclers as

[204] Shorter episodes of cold air incursions over Greenland given by Dawson et al., Greenland (GISP2) ice core, 430–433 for the early 1330s, the second half of the 1330s and the early 1360s did not go hand in hand with rainy and cold summer half years in England. This becomes clear from the annually resolved April–July temperature reconstruction and July to September precipitation index, as well as from evidence from other written records. The early 1330s were characterized by warm and dry growing seasons, 1331 was marked by a severe drought in spring and early summer (for the weather conditions of the summer half years in England see Sect. 6.2); dry conditions with average temperatures prevailed in the springs and summers in the second half of the 1330s. Campbell, Nature as historical protagonist, 299, notes that from 1332 to 1338 all grain harvests were favourable, 1333 and 1338 belong to the best in the period 1270–1429. In the early 1360s the spring and summer 1361 were extremely warm and dry in England. The period of high sea-surface temperatures 1323–1326 and the associated cold air incursion over Greenland 1323–1327 centres around the extreme dry summers 1325–1326, 1326 was also very warm. Interestingly, however, these dry and warm summer half years in northwest Europe which coincided with the warm events in the sea-surface temperature over the western North Atlantic and cold air incursions over Greenland often either started with or were predated by a wet and cold summer season. In the light of the indication by Jones et al., High-resolution palaeoclimatic records, 458 that dating in ice-core series is dependent on layer accumulation and layer counting, which becomes increasingly difficult with depth, i.e. increasing age of the ice core, it is important to outline this pattern. During the agricultural crisis causing the Great Famine 1315–1318, which coincided with a warm event in the North Atlantic, the extreme wet and cool summer conditions in England and northwestern Europe were concentrated in the earlier part of the crisis, 1314–1316. By 1317 weather normalized and 1318 saw a dry and warm summer season. The warm event in the North Atlantic 1323–1326 was preceded by the cold summer half year 1322, the high temperature event in the North Atlantic then started with the potentially cool and wet 1323, the event 1331–1333 was preceded by the appalling summer of 1330, the cold air excursion over Greenland 1336–1338 came after a wet and cold summer in 1335 and the warm event in the North Atlantic sea-surface temperatures 1350–1351 followed the extremely rainy summers 1348–1349, 1348 was also a cool summer half year.

[205] Campbell, Physical shocks, 29.

well as by the reeves and bailiffs who were eager to explain the severe impacts on agriculture and their unprofitable management of the manors. Most of the reconstructed very cold growing seasons are connected with bad harvests and partly even famine conditions; the incidence of murrains amongst livestock was also raised under very cold and wet spring-summer weather.

In warm and dry summer seasons the risks for harvest success were much lower and hence such years frequently escaped the notice of chroniclers and annalists. Additionally, wheat, the bread grain of the upper strata of society and also of the chroniclers, is drought resistant and much more likely to suffer from rain than dry weather. Barley can tolerate higher levels of humidity and is vulnerable to drought. In Norfolk it was the grain of the common people and exactly for that reason the state of the barley harvest was not of high interest to the literate classes.[206] Drought mostly only caught the attention of chronicles when it was extreme and hindered crop growth or impacted on human health, e.g. by affecting the reliability or salubrity of the water supply. It is noticeable that in England a number of plague waves occurred in years that saw high spring-summer temperatures. Contrary to the narrative sources, manorial accounts report the problems caused by dry weather for agriculture and pastoral farming. A lack of rain reduced the productivity of the hay meadows, pastures an d leguminous crops, and thus endangered not only the dairy sector but due to the lack of winter fodder the profitability of the pastoral sector as a whole.

6.7 Climate and Viticulture in Medieval England

The economically profitable cultivation of vines and the production of quality wine has become possible in England in recent decades; a period of global climate change and, in Europe, rising temperatures. Hence the popular mind takes the existence of viticulture in medieval England as an indication first of the temperature levels during the Medieval Climate Anomaly equalling contemporary climate, and second of modern day warming being neither due to anthropogenic influences, nor being outstanding in the historical context since the Medieval Climate Anomaly occurred in the pre-industrial period. The decay of English viticulture in the fourteenth century has been linked to the climatic deterioration at the onset of the Little Ice Age.[207]

The production of good-quality wine, however, was not the primary purpose of medieval English viticulture. Sugar-content and must-density are linked to temperature during the vine growing season, especially at its end in summer, so England was and remains at the northern limits of viticulture. Medieval wine-growing in climatologically disadvantaged regions similar to England, such as in northern or eastern Germany, was expected to give mostly sour wine, except in very warm and

[206] Hallam, The climate of eastern England 1250–1350, 124.

[207] Hyams, Viticulture in England, 33–35.

sunny years; this sour wine was consumed sweetened and spiced.[208] Thirteenth-century summers were warm (Fig. 5.4), and would at least partly allow for a high sugar-content in the grapes in England, but success or failure of the English vine harvest was by no means critical, as the country did not actually depend on home grown wine for drinking. Wine was brought to England from many French regions, Spain and the Rhineland; above all strong trade links with Gascony, where the English crown held extensive lands, favoured the mass import of quality wine.[209] The vines at Ely (Norfolk), named the 'l'isle des vignes' by the Normans,[210] illustrate the low importance of the quality of English wines. The grapes in the vineyard of Ely often did not ripen properly and only verjuice or sour wine could be made, nonetheless the vineyard was maintained, it was one of the longest-lived wine producers in England and is documented until 1469.[211] Given the climatological caveats it is not surprising that English wines did not impress foreigners, even though during the High Middle Ages they were occasionally fervently defended by the English themselves.[212] Nonetheless the products of the English vineyards found a ready market. Wine, which was not of the same quality as good drinking wine, found a use in cooking and in the celebration of mass. Grapes and verjuice, which was made from green, unripe grapes, were an essential ingredient in medieval cooking. Both, (sour) wine and verjuice were indispensable in medicine and certain special diets, for disinfection and (ritual) cleansing.[213]

In the rise and fall of English viticulture economic factors such as the price of wine, the price and availability of labour and commercial relations with the continent played an important role. With the Norman Conquest (1066) an invigorated interest in viticulture had taken hold in England and while in the 150 years after the conquest no preferred English 'wine region' can be detected, by the thirteenth century the southeast of the country had developed into the centre of English viticulture. However, wine-growing could be found as far north as Yorkshire,[214] and eastern England was dotted with vineyards. The Benedictine abbey at Bury St Edmunds (Suffolk) and the monastery at Thorney (Cambridgeshire) as well as the cathedral priories at Ely, Peterborough (Cambridgeshire) and probably Lincoln (Lincolnshire) possessed vineyards. More were to be found in Huntingdonshire, in Colchester

[208] Rösener, Bauern im Mittelalter, 112–113.

[209] Before the Hundred Years War, between 75,000 and 100,000 tons of wine were exported annually from the Gascon ports. England was the principal market for Gascon wine. Due to the war, wine exports fell drastically (70% from 1335–1336 to 1336–1337) and then fluctuated strongly, but never recovered to pre-war figures, James, Medieval wine trade, 9, 32–33, Unwin, Wine and the vine, 202–203. On the origin of the wines, see Henisch, Fast and feast, 119 and on the practice of the wine trade and the merchants, see Kermode, Medieval merchants, 207.

[210] Henisch, Fast and feast, 118.

[211] Jäschke, Englands Weinwirtschaft 374, Lamb, Climate. Past, present and future, vol. 2, 460.

[212] Henisch, Fast and feast, 118–119.

[213] Jäschke, Englands Weinwirtschaft, 286–289, Woolgar, Great household, 131, Henisch, Fast and feast, 120–121.

[214] Jäschke, Englands Weinwirtschaft, 361, Henisch, Fast and feast, 118.

(Essex) and at the manor of Forncett St Mary south of Norwich.[215] Norwich Cathedral Priory itself, as many other ecclesiastical institutions, was engaged in viticulture. It owned vineyards in Sedgeford and Plumstead, and possibly vines were cultivated in the cloisters of the cathedral priory itself.[216] None of these vineyards were extensive – the first vines in Sedgeford were planted within one day. The vines for Sedgeford were sent from Ely in 1263–1264, and more plants were brought to Sedgeford in 1273–1274. Viticulture in Plumstead is first mentioned in the account for 1312–1313. The lifetime of these vineyards appears to have been short: the last reference to the Sedgeford vines stems from 1327–1328 and no records survives for the vineyard in Plumstead after 1334–1335. Sedgeford and Plumstead were not untypical, discontinuity was a specific characteristic of medieval English vineyards.[217]

The establishment of the vineyard at Sedgeford in the middle of the thirteenth century falls within a period that was economically favourable for viticulture in England. The price of wine doubled during the thirteenth century. Whereas in the twelfth century commercial vine growing was largely unknown in England, Ely cathedral started now to sell its wine on the market.[218] The population in England was growing and stood between 4.75 and 7 million,[219] labour was abundant and cheap. Most ecclesiastical vineyards were in the possession of monasteries, and many vineyards were established in extensive manors which held a high number of *famuli*, permanent estate labourers of low social status. This work force was indispensable for the labour-intensive wine-growing.[220] All these features apply to Sedgeford and Plumstead: Sedgeford was the biggest demesne of the Norwich Cathedral Priory and Plumstead was also one of the bigger demesnes under plough.

The first reference to the vineyard in Plumstead in the account of 1312–1313 is relatively late. Most likely it was a thirteenth-century foundation, but had left no trace in earlier manorial documents. An installation as late as c.1310 would be an outright argument against any causal connection between viticulture and climate in England, because the years c.1290–1315 were marked by a raised interannual variability in the growing season temperature of up to 1 °C, and April to July were generally not as warm any more as between 1256 and 1290 (Fig. 5.4).

If climate would have been the determining factor for English viticulture in general and the vineyards of Sedgeford and Plumstead specifically, the crucial point

[215] Jäschke, Englands Weinwirtschaft, 297, 329–332, 351–353, Davenport, A Norfolk manor, 26.

[216] Saunders, Obedientiary and manor rolls, 112.

[217] Very few vineyards existed for a hundred years, see Jäschke, Englands Weinwirtschaft, 360–361. He supposes that the interruptions might be partly due to a lack of research or a lack of sources. On the vineyard in Sedgeford: Yaxley, The prior's manor-houses, 22; on Plumstead: ibid., 6. These small vineyards are not included in the study of Jäschke, Englands Weinwirtschaft.

[218] Jäschke, Englands Weinwirtschaft, 279, 374. An exception were the estates of the archbishop of Canterbury which included vineyards that aimed at market production, ibid., 377–378.

[219] The different estimations for the English population around 1300 are summed up by Britnell, Economic development, 11–12.

[220] Jäschke, Englands Weinwirtschaft, 324–328.

would have been the disastrous climate-induced agricultural crisis of the Great Famine and the following difficult years until 1323, which included not only a further sequence of cold and wet summers (Fig. 5.4), but also of very harsh winters (Sect. 6.4). These cool and wet summers must have resulted in wine of very poor quality, and the extremely cold winters had the potential to destroy the vines. Since the Sedgeford vineyard is still accounted for in 1327–1328 and the Plumstead vineyard in 1334–1335 they survived this period of climatic turmoil and persisted into a time that frequently saw warm and dry growing seasons, although the interannual variability of the growing season temperature was high (Fig. 5.4). Therefore it appears that these two vineyards rather succumbed to a reassessment at Norwich Cathedral Priory initially of specific sectors and then of demesne farming as a whole. The period of 'high farming' had come to an end, the prices for agricultural products had fallen in the mid-1320s, and the price-wage ratio made labour intensive cultivation less profitable for the landlords.[221] Most likely some time between 1330 and the mid-1350s Norwich Cathedral Priory's wine production fell victim to this development. Maybe the cold growing seasons 1330, 1335, 1347–1348 and the high precipitation levels of the 1342–1343, the mid- and late 1340s contributed to the abandonment of viticulture, but they can not have been decisive since 1315–1316, 1319 and 1322–1323 had not been so. The increasing scarceness of cheap labour and dropping profitability of demesne farming after 1350 would have prevented a reactivation of the vineyards; Sedgeford's and Plumstead's demesne under plough had fallen by a third due to the Great Pestilence (for Sedgeford see Fig. 2.3). Agriculture in Norfolk after the Great Pestilence was less labour intensive than before[222] and for a task as laborious as viticulture resources were scarce. Since these conditions were widespread in England, it is more likely that the vineyards that disappeared in the Late Middle Ages succumbed rather to the prevailing socio-economic trends than to cooling summers.

A look across the Channel provides the context for the situation of viticulture in the late medieval England. In continental Europe low grain prices in the late fourteenth and fifteenth century encouraged a diversification of crops, and in Germany wine-growing expanded into new territory towards the north and east. Viticulture also increased in fourteenth-century central and western France and northern Italy, as well as in the fifteenth-century on the territory of modern day Belgium.[223] The trend towards cooler summers can not have been instrumental in the end of the English vineyards, while wine-growing expanded in northern and eastern Germany and Belgium.

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[221] Stone, Medieval agriculture, 236–243.

[222] Campbell, Eastern Norfolk, 38–39 compares the eastern Norfolk demesne agriculture in the first quarter of the fourteenth century with the agricultural conditions of the first quarter of the fifteenth century: over that period the labour input of the permanent staff, the *famuli*, was cut by 26.8%; hired labour input was even cut further.

[223] Slicher van Bath, Agrarian history of western Europe, 144 and ibid. Slicher van Bath sees a clear connection between low grain prices and the increase of viticulture ibid., 144, 216–217. When grain prices increased vineyards would partly be converted into arable land.

English viticulture in the Middle Ages is not comparable to its counterpart of recent decades due to the wine-growers' different attitude towards the production of good-quality wine. Hence, the flourishing vineyards of the High Middle Ages are no proof in themselves for the summers of the Medieval Climate Anomaly being as warm or warmer than recent summers. When wine-growing decayed in England in the fourteenth and fifteenth centuries, the cooling temperature trend of the Little Ice Age played only a minor role, and some vineyards also operated in England during the Little Ice Age.[224] Consequently the existence of medieval vineyards provides no argument against the hypothesis of anthropogenic climate change. Summer temperature dropped between 1300 and 1400 in England and wine quality must have been reduced, but what changed in a much more fundamental way were population size and density as well as the availability and cost of labour. It was these changes and the import of wine from Gascony, Spain and elsewhere[225] that contributed largely to the end of most of the English vineyards during the Late Middle Ages.

[224] The vineyards are mapped in Jäschke, Englands Weinwirtschaft, 355–359 up to the sixteenth century.

[225] Unwin, Wine and the vine, 203.