



The Irish famine of 1740–1741: famine vulnerability and “climate migration”

S. Engler^{1,2}, F. Mauelshagen¹, J. Werner², and J. Luterbacher²

¹Institute for Advanced Study in the Humanities, Essen, Germany

²Department of Geography, Climatology, Climate Dynamics and Climate Change, Justus-Liebig-University Giessen, Giessen, Germany

Correspondence to: S. Engler (steven.engler@kwi-nrw.de)

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Abstract. The “Great Frost” of 1740 was one of the coldest winters of the eighteenth century and impacted many countries all over Europe. The years 1740–1741 have long been known as a period of general crisis caused by harvest failures, high prices for staple foods, and excess mortality. Vulnerabilities, coping capacities and adaptation processes varied considerably among different countries. This paper investigates the famine of 1740–1741 in Ireland applying a multi-indicator model developed specifically for the integration of an analysis of pre-famine vulnerability, the Famine Vulnerability Analysis Model (FVAM). Our focus is on Ireland, because famine has played a more outstanding role in Irish national history than in any other European country, due to the “Great Famine” of 1845–1852 and its long-term demographic effects. Our analysis shows that Ireland was already particularly vulnerable to famine in the first half of the eighteenth century. During and after the experience of hardship in 1740–1741, many Irish moved within Ireland or left the country entirely. We regard migration as a form of adaptation and argue that Irish migration in 1740–1741 should be considered as a case of climate-induced migration.

generally accepted as a caesura between two distinct periods of Irish history, “pre-famine Ireland” and “post-famine Ireland”. However, the term “pre-famine Ireland” does not at all imply that Ireland was a country without famines prior to the nineteenth century. On the contrary, Ireland had been struck by famine rather frequently throughout the Middle Ages and the early modern period (Crawford, 1993). As in other countries of pre-industrial Europe, many of those famines were the result of a complex interplay between social and environmental factors (Crawford, 1993).

In this article we investigate the Irish famine of 1740–1741, its pre-conditions, progress and consequences. Our main purposes are (1) to integrate social and climatic pre-conditions in a single, trans-disciplinary analysis; (2) to improve the knowledge of Ireland’s “pre-famine” famine history and thereby put the Great Famine of 1845–1852 into perspective. This is particularly important with regard to migration as a consequence of famine. Continuous mass emigration after the Great Famine caused the demographic disaster that made Ireland a shrinking society for many decades. Though this does make Ireland a unique case, it must be recognised that famine and migration had been connected throughout the eighteenth century (and probably earlier Fitzgerald and Lambkin, 2008). Therefore, it is an obvious question to ask if, or in what way, migration after the Great Famine followed already existing patterns that had partly been shaped by the experience of earlier famines.

Famine has regained attention today, when the world food problem is one of the greatest challenges (Wisner et al., 2004). What causes a famine, and how people adapt to famines, are still the predominant subjects of famine studies.

1 Introduction

Famines occurred frequently in the agrarian societies of pre-industrial Europe (Abel, 1974). Yet, they have left little or no traces in the narratives of national historiographies – with the exception of Ireland. The “Great Famine” that struck the country in 1845–1852 (Kinealy, 2006) has been given such an outstanding role in Irish national history that it is

Different theories – such as the Neo-Malthusian, the Food Availability Decline (FAD) and the Food Entitlement Decline (FED) theories – provide different answers to those questions. The FED theory of Amartya Sen (1981) dominated famine studies in the 1980s and 1990s. Its focus was on food entitlements distributed unequally among populations, i.e. the social conditions for food distribution, and not on alleged food availability. According to Sen (1984) “entitlement refers to the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces”. What Sen emphasises in his own case studies (Bengal 1943, Ethiopia 1972–1974 and Bangladesh 1974) is that during a famine only certain segments of the population suffer or die from hunger, while others still live in plenty. The concept of food entitlement replaced the idea of food availability as a tool of analysis, also in order to exclude any supposedly deterministic concepts connecting food availability with “natural causes” such as climate fluctuations (Fogel, 1992, 2004).

However, recent famines connected with long-lasting droughts in several eastern African states (Feed the Future, 2011) and the consequences of global climate change in general have put climatic extremes and other environmental circumstances back on the agenda of famine studies. Impacts of climate variability and extremes on food production and availability are particularly relevant in economies dominated by the primary sector, i.e. agriculture, which is the case in many developing countries today as well as in agrarian societies of the past. Determining the biophysical impact factors (BIF) of climate variations on staple crops has been one of the suggested approaches to understanding this relationship in specific places and for specific periods (Pfister and Brázdil, 2006). Variations in seasonal temperature, humidity, precipitation, solar radiation as well as atmospheric CO₂ concentration and soil condition are some of the most relevant variables affecting agricultural production (Reilly, 1999; Rötter and van de Geijn, 1999; Xoplaki et al., 2001). They directly determine the size and quality of harvests, the proliferation and aggravation of epidemics and indirectly influence the occurrence of hunger and famine.

Today, integrating FED and FAD theories and the social and natural circumstances of famine as well is still a challenge for famine theories and empirical case studies, which obviously require cooperation across the divide between natural and social sciences. To meet this challenge, we define famine “as an extreme scarcity of food or a drop in exchange entitlements in a certain region over a multi-year period that threatens the way of life of the already-vulnerable resident population and frequently leads to a higher mortality rate” (Engler, 2012a). Our methodology will be described in Sect. 2. Section 3 is dedicated to the European dimension of the crisis of 1740–1741. In Sect. 4 we provide a holistic analysis of the Irish famine of 1740–1741: Sect. 4.1 is an in-depth analysis of pre-famine vulnerability; in Sect. 4.2, using temperature and precipitation reconstructions from Luterbacher

et al. (2004, 2007), Xoplaki et al. (2005) and Pauling et al. (2006), we describe climate conditions in Ireland between 1739 and 1741; Sect. 4.3 looks at the impacts on, and coping strategies of, Irish society; finally, Sect. 4.4 deals with adaptation processes in the aftermath of the famine. Here our main focus is migration as a form of adaptation, and we will discuss the question of whether migration in the context of the Irish famine of 1740–1741 may be regarded as a case of climate-induced migration.

2 Methodology

The theoretical framework we use in our analysis of the Irish famine of 1740–1741, is provided by the “Famine Vulnerability Analysis Model” (FVAM) developed by Engler (2012a). The FVAM is a heuristic tool, designed to support the study of a wide range of famines over space and time. Emphasising the study of the pre-famine phase, it seeks to advance existing vulnerability concepts by Birkmann (2006), Bohle (2001), Füssel (2007), Pahl (2006) and Turner II et al. (2003). Pre-famine vulnerability studies people’s livelihood and its socio-economic context, before the initial drivers start affecting them. By contrast, the focus of most other models is entirely on the impacts of famine and on coping strategies to mitigate these impacts (Engler, 2012b).

The concept of “vulnerability” has emerged from the wider framework of geographical and sociological studies of disaster as a key to uncovering the geographic, social and economic preconditions for disastrous events and their complex interplay (Blaikie et al., 1994; Oliver-Smith, 1994; Cutter, 1996). However, in the face of its almost inflationary use today, there is a need to define “vulnerability” (Füssel, 2007). As a working definition we quote the Intergovernmental Panel on Climate Change (IPCC), which defines vulnerability “as the propensity or predisposition to be adversely affected. Such predisposition constitutes an internal characteristic of the affected element. In the field of disaster risk, this includes the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the adverse effects of physical events” (IPCC, 2012; cf. Wisner et al., 2004). As Collet (2012) has pointed out recently, the investigation of predispositions refocuses the study of disasters (such as famines) replacing an existing focus on their analysis as events (particularly fashionable among historians) with the examination of more long-term historical developments before the onset of a disaster. In other words, understanding vulnerability adds historical depth to the study of disasters and makes them discernible as processes rather than events (Oliver-Smith, 2004).

In our assessment of pre-famine vulnerability we seek to evaluate as many of the factors distinguished in the FVAM as possible. Our conclusions will be summarised by attributing an index to each factor. We apply a simple three-value index

ranging from -1 to $+1$. Whereby “0” means that an indicator is considered to influence vulnerability neither positively nor negatively, whereas “1” signifies that a given indicator is considered to have aggravating effects on famine vulnerability, and “ -1 ” that a given indicator is considered to have mitigating effects. Although the FVAM is composed of factors of vulnerability that we consider to be generally relevant and applicable to historical contexts, there are exceptions to this rule that necessitate modifications of our model. Historical evidence is sometimes sparse and incomplete and therefore does not allow an unambiguous evaluation of certain indicators. In such cases, the respective indicator will be marked with the sign \emptyset , and it will not be counted in our overall assessment. We use \emptyset for indicators that do not apply to the respective historical context (in our case, Ireland in the first half of the eighteenth century).

In case all indicators allow evaluation, the sum total of our pre-famine vulnerability assessment ranges from -34 (vulnerability minimum) to $+34$ (vulnerability maximum). Given this full range, we suggest a provisional distinction between five types of famine vulnerability: A highly resilient¹ society (-34 to -20), a resilient society (-19 to -6), a society in danger (-5 to 5), a vulnerable society (6 to 19) and a highly vulnerable society (20 to 34). However, it must be stressed that our indexation cannot represent any relative or comparative assessments among indicators; in other words, indicators are not weighted against each other. Nevertheless, in concrete contexts, some may be more important than others, such as the indicator group “agriculture” for the analysis of rural societies. Therefore, as well as for other obvious reasons, calculating a sum total from our indices does not lead to a precise quantification of vulnerability and requires caution when used for comparison. With these constraints in mind, the method of the FVAM still claims to be of considerable heuristic value for any future comparative study of famine vulnerability.

In designing the FVAM, complexity and flexibility were among the most desired features. The model integrates a wide range of factors worthy of consideration for a complex assessment of vulnerability. At the same time, its complexity needs to be combined with flexibility so that the model can be applied as a research tool to varying historical contexts. Based on an evaluation of the literature on famines around the world between 1315 and 2012, Engler (2012a) distinguishes four chronological phases, also reflected in the structure of this article: first, pre-famine vulnerability; the second phase is characterised by the initial driver, e.g. climate (as in our case), failures of political crisis management and other social or environmental circumstances such as wars or microbial shocks (Engler, 2012a). Coping capacities/strategies

and direct impacts on a group or society are major subjects of phase three. The adaptations to famine crises constitute the fourth phase. Major processes such as migration or learning processes belong to the adaptation phase, but also link this phase to others (Engler, 2012b). These connections and feedback loops amongst the phases make the FVAM a complex tool of analysis (Fig. 1).

In order to apply the FVAM to historical cases such as the Irish famine of 1740–41 our theoretical approach must be supplemented by conventional historiographical methods (archival research, source criticism, etc.). The main source of information used in this paper is the existing research literature on Irish history (particularly on historical famines) and historical geography. In addition, archival research has been carried out to include information from local Irish newspapers, letters, books, diaries, official records, and other documents related to the famine of 1740–1741. The statistical information, e.g. on burials and marriages as well as reconstructed grain prices, has been drawn from both research literature and primary sources. Last but not least, we assess the climatic conditions of 1740–1741 using climate field reconstructions because of their importance for the occurrence and further dispersion of the famine. All of the reconstructions used are based on first decomposing the proxy and instrumental data into the leading modes of variability and then performing a multivariate regression between the resulting time series. One purported advantage is the inclusion of long-range correlation structures, leading to predictive skill even at locations where no data is available for the past (Smerdon et al., 2011). Thus, even while these studies did not use predictors from Ireland, validation measures in these studies do indeed indicate skill for our area of interest (Luterbacher et al., 2004; Xoplaki et al., 2005; Pauling et al., 2006). Recently, it has been shown that even without explicitly including teleconnection patterns, reconstructions can still be skilful outside the area with good data coverage in the past (Werner et al., 2013).

3 The general character of the crisis

For quite a while, economic historians have recognised that the crisis of 1740–1741 was one of European scale (Abel, 1974; Mauelshagen, 2010). For us it is important to see the Irish case in this wider context. The general character of the crisis provides ample opportunity for comparison and thus for relative historical assessments of vulnerability. The stresses in 1740 were manifold: first, harsh climate conditions were experienced in large parts of Europe (Fig. 2). During the winter of 1739–1740 Europe experienced very low temperatures. In Central and Eastern Europe the temperatures were $3\text{--}4^\circ\text{C}$ lower than in the reference period of 1961–1990 (Luterbacher et al., 2004, 2007; Xoplaki et al., 2005). Most parts of Southern Europe and the whole northwest also experienced lower temperatures (Fig. 2; upper left panel). In

¹According to Füssel (2007) “resilience focuses on the ability of the system to maintain its basic functions and return to the original state after a perturbation”. In this view, resilience is complimentary to vulnerability.

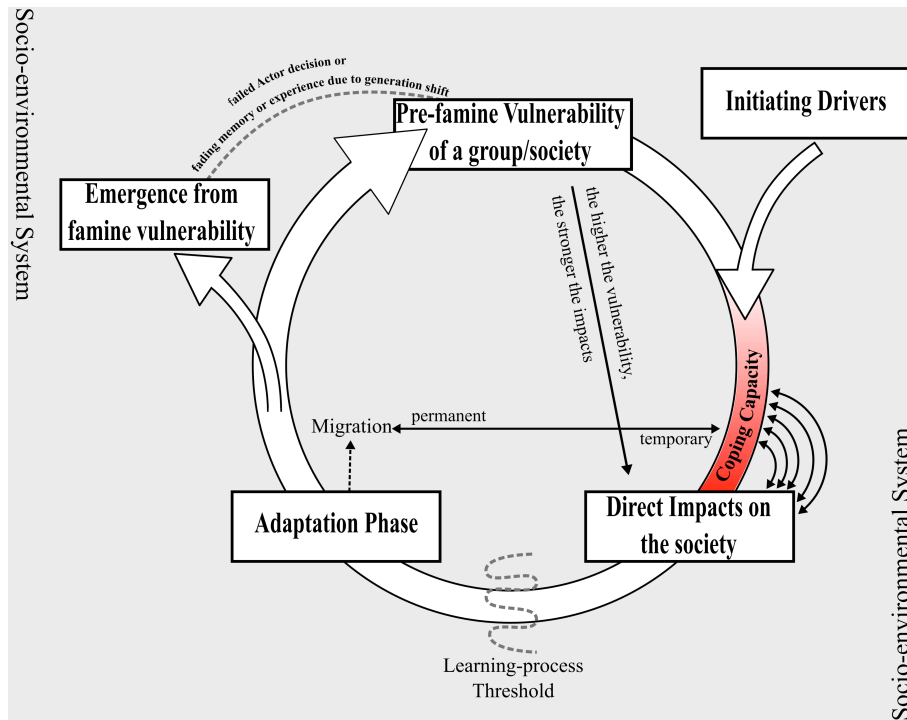


Fig. 1. Famine vulnerability analysis model (Engler, 2012a).

spring 1740, low temperatures persisted (Fig. 2; upper right panel). In June, July, and August 1740 Ireland, Great Britain, France, Germany, the Czech Republic, Poland and the southern parts of Scandinavia still suffered from temperatures that were between 0.8 and 2.4 °C lower than normal (Fig. 2; lower left panel). Autumn 1740 was again characterised by below average temperatures (Fig. 2; lower right panel).

Second, as a consequence of bad harvests, increasing grain prices severely affected many European regions (Abel, 1974). Between 1735 and 1740, grain prices in Berlin, Hamburg, and Augsburg rose between 160 and 280 % (Abel, 1974). For the same period prices also increased in other European regions (Table 1). The prices for breadstuff rose between three and five times at the Danish Sound Passages (Abel, 1974).

Third, a great mortality wave hit Europe. Summarising his research, John D. Post (1984) stated “that climatic variability touched off concurrent epidemics of less fearful diseases which proved capable of producing European mortality waves”. For Post (1984) the rising prices of grain and fodder between 1739 and 1741 indirectly influenced the relation between climate and mortality and acted as an intensifier. Table 1 refers to this indirect connection and gives numbers for several European countries. Even though 1740 and 1741 were years of hardship and suffering in great parts of Europe, the population of Ireland was struck particularly severely by the “Great Frost”, which started at the end of 1739 (see also Sects. 4.3 and 4.4).

Table 1. Development of grain prices and mortality in different European countries, 1735–1744 (adapted table from Post, 1995).

State	Increase in grain prices from 1737–1738 to 1740–1741 (in %)	Increase in mortality from 1735–1739 to 1740–1742 (in %)
Low countries	77	22.3
Denmark	71.4	10.1
Finland	67.1	51.8
Sweden	60	22.7
Ireland	56.7	25.3
Scotland	52.9	21.1
Germany	47.9	3.9
Norway	44.1	81
Italy	37.2	10.4
France	35.7	24.5
Austria	33.7	1.9
England	32.9	23.4
Switzerland	30.7	17

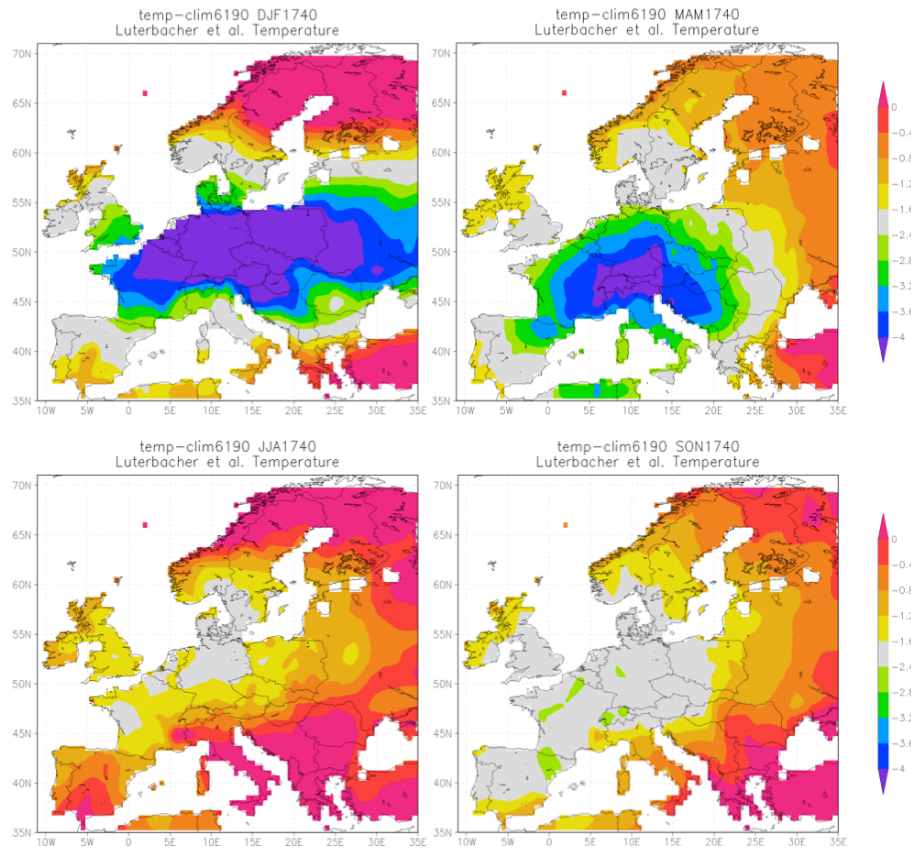


Fig. 2. Temperature anomaly (with respect to the 1961–1990 reference period) for the December to February average (upper left panel), March to May average (upper right panel), June to August average (lower left panel) and September to November average (lower right panel) 1740, is taken from the reconstruction of Luterbacher et al. (2004, 2007) and Xoplaki et al. (2005). The figure was plotted using the KNMI Climate Explorer.

4 The Irish famine of 1740–1741

4.1 Vulnerability in pre-famine Ireland

According to the model applied in this study (see section two), our analysis of pre-famine vulnerability is based on an evaluation of 30 (in this case study four of the original indicators do not apply in this specific context) social and environmental indicators. Compared with the theoretical development of the FVAM as presented by Engler (2012a,b), some of the indicators and indicator groups have been slightly modified. Table 2 summarises the result of our assessment of vulnerability in Ireland before the crisis of 1740–1741. In the following subsections (4.1.1 to 4.1.4), we will substantiate our assessment of social and environmental vulnerability by clustering sets of related indicators in the indicator groups shown in Table 2 (population, politics etc.).

In the course of applying the model to Ireland in 1740–1741, some methodological problems occurred that required decisions on how to handle them. In the following we explain the most important principles for our assessment of the variables:

1. Application of the FVAM model (like any other model consisting of a list of indicators or variables) to specific cases of famine requires subsumption of relevant historical facts (correct information) to indicators. Subsumption is based on selection and judgement, the quality of which depends on the state of knowledge (or research) and professional expertise (in our case: historical and climatological expertise). Facts subsumed under indicators become arguments for our assessments, which means that we select information we consider important for our assessment.
2. An important element in the expertise of historians is awareness that the facts they select have already been pre-selected and that that pre-selection is irreversible and may produce biases in historical judgement. For obvious reasons, the theoretical design of the FVAM required modification because some of the indicators could not be treated independently or sufficiently as regards the available information.
3. Many of the indicators are interrelated, and that interrelationship may be intensified in specific historical

Table 2. Assessment of pre-famine indicators of vulnerability for the Irish Famine of 1740–1741: numbers in brackets represent the index value according to our assessment of single indicators.

Social vulnerability (SV)	<i>Population</i>
	1. Population size and growth (1)
	2. Urbanisation ratio (0)
	3. Social classes (1)
	4. Marginalisation or inequality (1)
	5. Exchange entitlements (1)
	6. Dependence structure (1)
	7. Fresh water accessibility (−1)
	<i>Politics</i>
	8. Governance structure (1)
	9. Political systems (1)
	10. Relief systems (1)
	11. Health system (1)
	12. Education systems (1)
	13. Power struggles (internal or external) (1)
	14. Legal structure (1)
	15. National borders (Ø)
	<i>Economy</i>
	16. Market integration (1)
	17. Infrastructure (1)
	18. Tax structure (Ø)
	19. Labour market situation (Ø)
	20. Economic opportunity (1)
	21. Financial structure (Ø)
	22. Grain prices or prices of staple foods (0)
	<i>Agriculture</i>
23. Agricultural diversification (1)	
24. Agricultural techniques (1)	
25. Famine history and memory (0)	
26. Diversity of species (1)	
Environmental vulnerability (EV)	<i>Environment/climate</i>
	27. Geographical position (−1)
	28. The population’s perception of climate (1)
	29. Temperature conditions (1)
	30. Precipitation conditions (1)
	31. Mean temperature during the growth period of staple crops (1)
	32. Mean precipitation during the growth period of staple crops (1)
	33. Influence of other forcings (1)
	34. Fresh water availability (−1)

contexts. Practically, this means that points made in the explanation of an earlier indicator or indicator group will be referred to later. Though obviously unavoidable, this raises questions if counting each indicator separately is justifiable in every single case. At this point we must once more stress that the summing up of our evaluations based on the indices (−1, 0, +1) does not lead to precise quantification.

4. Basic to most of our assessments of single indicators is a comparison of Ireland with other European countries, though we are lacking the space here for anything like

a comprehensive comparative approach. Thus, comparison is not systematic, but based on historical expertise.

5. One of the strengths of an approach that investigates pre-famine vulnerability is that it considers historical circumstances that are not just short-term. The information we use points to processes of varying temporal depth – an element that deserves further investigation to better understand the temporality of the underlying processes.

4.1.1 Population

Prior to the availability of census data (from 1821 onwards), Ireland’s population history relies predominantly on estimates based on hearth counts for tax registration. There has been some debate about how under-recorded hearths (households) were in the history of the tax and what multipliers need to be applied in order to calculate reliable population numbers (Connell, 1950; Daultrey et al., 1981; Dickson et al., 1982). As a consequence of different solutions to these problems population estimates vary considerably. However, in the context of vulnerability, absolute numbers are less relevant than growth rates, because population growth challenged early modern societies to increase agricultural production by equivalent amounts, often forcing them to cultivate wastelands with less-fertile soils. Demographers agree that the Irish population grew rapidly, and above European average, around the turn from the seventeenth to the eighteenth century, but stagnated in the decades before 1750, before rapid growth set the stage for the disaster of the Great Famine, after which emigration led to population decline throughout the nineteenth century (Table 3). Though it would be too simple to regard the famine of 1740–1741 merely as the end of a Malthusian cycle, the decades of excess population growth before and after 1700 certainly had their share in the overall vulnerability of Ireland’s society.

Like all other pre-industrial countries, Ireland “was predominately rural” (McCracken, 1986). McCracken (1986) gives a ratio of 12.5 % for the urbanised population in 1725, Kennedy and Clarkson (1993) estimated that only 7 % of the population lived in towns bigger than 10,000 for the mid eighteenth century. Though significantly lower than in England or the Dutch Republic, the degree of urbanisation resembled that in continental Europe or Scotland. Ireland fell behind the general trend of accelerated urbanisation in Europe only after 1750, when the urban percentage “remained practically unchanged until the [Great] Famine” of 1845–1852 (Kennedy and Clarkson, 1993). It is difficult to assess the role of urbanisation as an element of social vulnerability independent of other factors such as social structure or taxes. However, a higher or growing degree of urbanisation per se might indicate a greater importance of markets over sheer subsistence in the overall structure of an economy, that is, either in relation to each other, or in a comparison between

Table 3. Synopsis of estimates of Irish population numbers and average annual growth rate by indicated period (in parentheses), 1687–1901. Numbers are based on Connell (1950), Dickson et al. (1982), and Clarkson (1981). Census data are available from 1821 onwards. The synopsis has been modified from Kennedy and Clarkson (1993).

Period	Connell	Dickson et al.	Clarkson	Census
1687–1725	2.2 → 3.0 (0.8)	2.0 → 2.2/6 (0.5)	1.7 → 2.2 (0.7)	
1725–1753	3.0 → 3.2 (0.2)	2.2/6 (0.0)	2.2 → 2.3 (0.02)	
1753–1791	3.2 → 4.8 (1.1)	2.2/6 → 4.4 (1.6)	2.3 → 4.2/6 (1.7)	
1791–1821	4.8 → 6.8 (1.4)	4.4 → 6.8 (1.7)	4.2/6 → 6.8 (1.7)	1821: 6.8
1821–1841				6.8 → 8.2 (0.8)
1841–1901				8.2 → 4.5 (−.0)

countries. Moreover, in the specific context of famines, market integration, which may be regarded as a historical consequence of urbanisation, has been considered a mitigating factor in coping with food scarcity and rising prices for staple crops (Persson, 1999). However, both the early modern discourse about food speculation as well as the more recent impact of such speculation on global financial markets raises doubts as to whether the effects of market integration are unambiguous. At this point, we are lacking a general indication. Therefore, we must limit our assessment of the role of urbanisation in social vulnerability to historical comparison between Ireland and other European countries before and around the crisis of 1740–1741. Thus, the fact that the difference between Ireland and the rest of Europe became significant only after 1750 is the most robust foundation for our assessment of this indicator.

Generally speaking, the famine was neither an exclusively rural nor urban event. The prevailing social inequalities, religious discrimination, and great poverty led to this vulnerability and raised food insecurity even further. A contemporary witness from Cork describes some of these differences: “There is in no kingdom greater inequality than in Ireland: one class of great property who live excessively sumptuous: the second and more numerous class hurting their fortunes by the imitation of the first – the third in extreme poverty” (O’Brien, 1918).

4.1.2 Politics

The vulnerability of political systems and the corresponding institutions and structures are at the centre of our second indicator group. Today, “good governance” has become a term in political science to measure the performance of political systems to manage contingency and crises – a form of management in which representatives of the state, economy, and civil society are required to cooperate in all questions of strategic planning (Benz et al., 2007). Though the modern concept of “good governance” does not easily apply to historic contexts, it is not entirely detached from early modern ideas of “good government”. However, these ideas hardly provide a reliable catalogue of criteria to assess the impacts of political management on famine vulnerability. What can

be said in the case of Ireland is that, whatever attempts there were at “good government”, these attempts were complicated immensely by political and religious disruptions.

Since the sixteenth century Ireland was under the control of the English kingdom, which was mostly Protestant. The so-called “plantations” were regions in Ireland that were annexed and colonised by English and Scottish settlers in the course of the sixteenth and seventeenth centuries. These areas were primarily in the North of Ireland (Ulster), but also existed in the Southwest and in the centre of the island (Cruise O’Brien and Cruise O’Brien, 1985). These external political as well as religious influences provoked social conflicts and increased vulnerability in the context of food scarcities and famines. The Penal Laws excluded Roman Catholics, who represented by far the biggest population group, entirely from political participation. Between 1728 and 1793 the Roman Catholics were strictly banned from all governmental duties and had neither passive nor active voting rights (McCracken, 1986; Smyth, 2006). This increased their vulnerability immensely, especially in the field of agriculture and food production, because individuals who were not interested in the needs of the rural, Roman Catholic population made decisions on exports and imports, price cutting strategies, etc.

In addition to the discrimination of the Roman Catholics through the “Penal Laws” (Cruise O’Brien and Cruise O’Brien, 1985), other laws complicated the operation process of certain economic sectors and raised the vulnerability of those involved. For example, the woollen manufacture got into distress, because of the numerous production-limiting laws. As a consequence, 20 000 employees emigrated to seek better chances abroad (O’Brien, 1918).

In the areas of health care and famine relief, Ireland lacked the basic structures to manage food scarcity and to strengthen the population’s resilience. At the beginning of the eighteenth century, Ireland’s health system was just starting to be established. Health services were predominantly based on charitable private investments to treat the sick and poor (Harvey, 2007). The already established hospitals and infirmaries were mainly located in Dublin (Pringle, 2012). In addition, a relief system was generally absent in 1740–1741.

In the context of famine, we define a relief system as an organised form of food aid from private actors or public institutions, ready to answer the demands of the specific crisis. Nation-wide charitable actors – with the exception of the Church – or a political welfare system did not exist – a circumstance also noted by contemporaries (Stephens, 1746; Prior, 1741). Post (1995) considers “the combination of the severe food shortages and the ineffective or absent welfare and relief measures” to be the primary cause for high mortality in 1740–1741. Though that applies to other European countries as well, Ireland was clearly among the most vulnerable in terms of preparedness. As we shall see, in some Irish towns private agents or institutions did start some measures of poor relief during, but not before, the famine. Such local activities were sporadic and short-term. The city of Cashel was one of the exceptions to the rule and took action, already when the first symptoms of famine became discernible: “The great charity of this little town [Cashel] has brought above a thousand poor together, who are fed every day in the most regular manner of any I hear in any town in the kingdom; [...] I wish all the towns in the kingdom wou’d take pattern” (George Faulkner, *The Dublin Journal*, 1741).

Only after the famine of 1740–1741, the need for a widespread health and relief system became a more pressing issue of “good government”.

Today, education is widely accepted as a pre-condition to achieving food security. The “Food and Agricultural Organization of the United Nations” has argued that the “lack of education undermines productivity, employability and earning capacity, leading directly to poverty and hunger” (FAO, 2005 cited in FAO, 2007). This does not only apply to modern societies with their highly diverse labour markets, but also to pre-industrial societies such as Ireland in the first half of the eighteenth century. Like almost any other element of social life, modernisation of education in Ireland was obstructed by the circumstances of English colonial rule reinforcing inequality along the lines of the Catholic–Protestant divide. As early as the 16th century, Henry VIII and Queen Elizabeth I had used education as “cultural weapon” to establish the English tongue and the Anglican Church in Ireland (Fallon, 2005, 118 pp.). The parish, diocesan, royal, and charter schools endowed through government or parliamentary grants reached out to upper or middle-class Protestants, but not to lower-class people and the Catholic majority (Akenson, 1970). Penal legislation in the 17th century outlawed Catholic priests and teachers. As a result, “both professional schools and the Catholic parish schools ceased to exist” (Fallon, 2005). Instead, parents would send their children to underground “hedge schools” (called in Gaelic *scoil chois clat*, *scoil ghairid*, or *scoil scairte*, etc.) for the “rudiments of learning” (Fellon, 2005). The Irish charity school movement in the early eighteenth century responded to these developments. Charity schools enrolled both Protestant and Catholic children of the lower classes, “but instruction was in the protestant religion only” (Akenson, 1970).

The medial revolution triggered by the printing press impacted Ireland only after 1750, although the art of printing had been introduced into Ireland two centuries before. Yet, “It failed to capture the imagination of the Irish people” and “was looked upon as an English institution” (Fallon, 2005). Particularly striking is the high illiteracy rate. It correlates positively with Gaelic as the spoken language, the Catholic religion, and non-existing communication paths (Smyth, 2006). Illiteracy was comparatively low in today’s Northern Ireland (between 40 and 60%) and Dublin (under 40%), while it was over 80% in the West and Southwest of Ireland (Smyth, 2006). We are, of course, aware that oral communication and traditional forms of education were a form of knowledge transfer operating in many traditional societies. Its value should not be underestimated. However, improvements in literacy and education of rural populations became an important element in the efforts to improve agricultural production almost everywhere in Western and Central Europe in the first half of the 18th century. Ireland had clearly fallen behind those developments.

English rule fostered religious and, with it, regional divergence, and it provoked social and political protest. In addition to all other negative political aspects, the whiff of war with Spain and France lay over the kingdom and the military expenses rose, even in times of famine (Magennis, 2000).

4.1.3 Economy

Like in other parts of pre-industrial Europe, agriculture was the dominant economic sector in Ireland, and we will deal with it separately in the following section (4.1.4). In the present section our focus is on other sectors and features of the Irish economy that affected the vulnerability of the Irish population to famine. However, it must be stressed that the pre-dominance of agricultural production caused a number of important consequences: (1) landowners formed the most influential group to either foster change and improvement or to resist it, which is true not only for the agricultural sector, but also for early forms of industrial production in the textile and mining industries (Proudfoot, 1993). (2) Irish exports consisted largely of raw, unprocessed goods. (3) Moreover, production was less commercialised compared with England or the Dutch Republic, which means that Ireland represents a case where most production merely served subsistence. Commercialisation of goods progressed during the eighteenth century. However, the improvement of economic exchange was confronted with structural deficiencies that also potentially increased Ireland’s vulnerability to famine.

In the literature on famine, market integration has generally been recognised as a structural feature that influences price volatility of staple foods. Studies on Prussia (and elsewhere) in the nineteenth century have shown that regionally well-integrated markets have a tendency to level out high prices in times of food scarcity (Persson, 1999). Lowering the costs of transportation is generally considered the

key improvement in fostering transition from low levels of market integration to higher ones. Improvements of Ireland’s transport infrastructure were established mostly after 1750. Water transport, which dominated trans-regional exchange, was improved by canal construction in the second half of the eighteenth and in the nineteenth century; only for some canals construction began earlier (Delaney and McCutcheon, 1984). Between 1730 and 1750, road construction depended on so-called turnpike trusts (self-financing commercial ventures), while parishes were not responsible to build new roads. The turnpike system more or less failed because the costs for construction and maintenance were hard to cover (Proudfoot, 1993). As regards road quality, contemporary reports diverge significantly, which is hardly surprising. Roads in and around Dublin were reported to be in good shape; but road quality deteriorated with the shrinking size of towns or villages and their relevance for trans-regional trade (Smyth, 2006).

English colonial rule in Ireland affected Irish trade with the rest of Britain and beyond. While Irish merchants had to pay taxes on exports to England, which lowered their profits, exports from England to Ireland were more or less tax-free. Free trade with other European countries, e.g. Spain, was entirely prohibited (O’Brien, 1918). Also trade embargoes by specific cities inside Ireland further harmed other regions and the market as a whole during the famine. Cork and Belfast were only two examples for this particular behaviour. Cork mostly stopped incoming ships from America, and Belfast stopped all ships in their harbour as soon as food shortages became discernible (The Belfast News Letter, 1740).

4.1.4 Agriculture and environment/climate

The dominance of agriculture, or the primary sector of economic production, is essential in understanding the vulnerability of pre-industrial economies to climatic variability and extremes. In the centres of agricultural production (e.g. Europe, China), over hundreds or thousands of years human populations had established co-evolutionary relationships and ecological cooperation with a relatively small set of plant and animal species – small by the standards of hunter-gatherer societies which accessed a much greater variety of species. Domestication of species used in agriculture developed over the long-term and created locally highly diverse and complex patterns of vulnerability of food production to climate fluctuations. Summarising this point of general importance as early as 1922, Lucien Febvre (1924), one of the founding fathers of the French School of *Annales* historians, emphasised in his geographical introduction to the study of history that “the action of climate on the natural environment in which man lives must be known before we can understand the action of climate on man.” The equilibrium between climate and agriculture was (and is) particularly delicate in mountainous regions, e.g. in the Alps, the Himalayas, or the Andes, and in latitudes bordering climate zones where

agriculture becomes risky, which includes certain parts of northern Europe.

In view of the great significance that weather conditions had for the success or failure of crops during growing season, it is remarkable how little Malthusian or Neo-Malthusian, FAD and FED theories of famine, but also historians of agriculture, have cared about climate, the weather and other environmental circumstances. For the purpose of our study we must re-integrate what belongs together. We therefore discuss environmental factors and agriculture in a single indicator group. This also includes weather/climate perceptions and memories of extreme events, because these cognitive elements operate at the intersection between society and the environment and, thus, influence the adaptability of individuals and societies to climatic variability and their resilience (Walker et al., 2004).

Agriculture is of cardinal importance for Irish history (Ó Gráda, 1990), which is influenced by specific climate conditions. Due to its geographic proximity to the “Gulf stream” (North Atlantic Drift), Ireland normally has a climate characterised by comparatively mild winters and cool summers (Goodale et al., 1998). Some of the cold spells that affected continental Europe, and were typical for the period known as the “Little Ice Age” (LIA), spared Ireland or were less severe there. As regards precipitation, Ireland shows large regional differences between the western and the eastern parts of the island. “For sites at sea level, annual precipitation ranged from more than 2000 mm in the west to less than 800 mm in the east” (Goodale et al., 1998). In years diverging from these “average” conditions of Irish climate, extreme events and anomalies often led to food scarcity affecting various segments of society (Crawford, 1993).

Looking at the state of the primary sector of economy in early eighteenth-century Ireland reveals some of the social and environmental disharmonies that are characteristic for that country. All societal processes were bound to the crop cycle. Since the potato had crossed the Atlantic, it had become one of the two main staple foods in Irish agriculture (the other one being oats) prior to and in 1740 (Salaman, 1985). Though the potato probably helped Ireland’s growing self-sustaining rural population to survive, the monoculture-type of food production it fostered certainly increased the vulnerability of the Irish society for climate and environmental impacts particularly dangerous for the potato and oat.

Adding to the lack of diversification were other insufficient practices of agricultural production. By these practices we refer to techniques of storage, and also include agricultural knowledge and cultivation methods. First, appropriate storage of surplus corn in good harvests were missing in Ireland (Powell, 1757). Second, the farmers did not use the tillage system efficiently enough, as some contemporary observers pointed out: “It is certain that the tillage of the kingdom does not bear a sufficient proportion to the wants of the inhabitants” (Powell, 1757). Furthermore, forest clearance for ship construction and the extension of cultivable land was

followed by a set of environmental problems (Smyth, 2006) such as soil erosion. The rapid destruction of woodlands also destroyed the habitats of some domestic animals.

Environmental decline was also experienced by the fishing industry, which faced major difficulties in the early 1700s. Historical research and reports by contemporary witnesses indicate that the former abundance of fish stocks in the Irish Sea was declining. According to Lecky (1913) “the wasteful system of trailing nets, however, which was illegal in France, had been introduced into the Irish fisheries about 1738, and the destruction they caused among the seaweed and among the spawn is believed to have been the cause of the decline of the fisheries.” This situation forced many traditional coastal towns to shrink, both economically and demographically.

Weather perception is instrumental in the interaction of rural societies with their local environment. The memory of hardship caused by extremes has always been particularly significant in this framework, and it is obvious that without memory there is no preparedness. The three decades prior to the famine were characterised by relatively mild winters (Rutty, 1770). Thirty years are equal to a full generational shift, certainly by the standards of the average Irish life expectancy in the eighteenth century (Schellekens, 1996). Dickson (1997) already assumed that this experience “perhaps lulled people into a sense of false security as regards their food supply”. Thus it seems likely that the Irish population in 1740 was hardly prepared for the unexpected for a lack of memory of a cold winter followed by harvest failures. Thirty or more years would have counted less, was it not for the highly illiterate rural population for which written memory of previous famines was hardly accessible. Records of extreme weather events, climate fluctuations, and famines for previous decades and centuries were only accessible for small segments of the society. As a matter of fact, a lot of Irish newspapers reported on those events and linked them to expected harvest outcomes in rural areas (The Dublin Gazette, 1740a), but they did not reflect on previous famines (such as 1728–1729). Newspapers were printed and read mainly in cities. In rural areas, the clergy at best, indirectly communicated such reports. Overall, many aspects indicate that a great majority of the Irish living in 1740–1741 only had a very short-term and (at best) fragmentary memory of previous famines caused by climatic extremes. This clearly contrasts the situation after the “Great Famine” of 1845–1852 (Kinealy, 2006).

4.2 Initiating driver

As discussed in the previous sub-section, Ireland had been on the brink of a famine for several years. However, the extreme winter of 1739–1740 and the still too dry spring seem to have caused the situation to tip.

“For several days past we have had here very cold weather, but Sunday and yesterday, most excessive cold, with hail and snow, and not three hours of continued rain since the

beginning of November, which causes as great scarcity of water as in the midst of summer, so that there is no getting corn ground at our water mills” (The Dublin Gazette, 1740b).

The records of purely qualitative weather descriptions from archives need to be verified using quantitative data. We use the seasonal temperature and precipitation reconstructions for Ireland by Luterbacher et al. (2004, 2007), Xoplaki et al. (2005) and Pauling et al. (2006). In Fig. 3, we present seasonal climate diagrams for temperature and precipitation (Luterbacher et al., 2000, 2004, 2007; Xoplaki et al., 2005; Pauling et al., 2006) for the early eighteenth century (1710–1739), the 30 yr prior to the famine. A solid red vertical line marks the average values for the reference period 1961–1990 and blue dashed lines mark the respective seasons in the famine years of 1740–1741. The pre-famine situation seems to have been roughly comparable to the situation in the late twentieth century (Fig. 3). The autumn of 1739 was already slightly cooler than normal (1 °C). The winter of 1739–1740 was even cooler (about 2 °C) and much drier (–30 % precipitation) than the previous years. Contemporary witnesses also noted the unusually cold weather, as can be seen from newspaper reports like the following, printed in the Dublin Gazette in January 1740: “The frost continues most severe and intense, so that there are tables and forms on the Liffey and selling liquors, and it is said they intend to roast an Ox on it. The thermometer is four degrees lower and colder since our last, and is now 7–9 degrees colder than ever has been known” (The Dublin Gazette, 1740c).

The dry winter and spring of 1739–1740 had a huge influence on crop yields for the following year as the saplings withered: the influence of detrimental weather on plant life, especially on annual plants, is much higher during the beginning of the vegetation period than later in the same year.

Luterbacher et al. (2002) argue that possibly a stable high-pressure ridge over the eastern Atlantic was dominating mid- and upper-tropospheric circulation flow during winter 1739–1740 (Figs. 4 and 5). The corresponding low-pressure systems extended from the Canadian Archipelago down to Labrador and to the Black Sea. The ridge over the eastern Atlantic led to stable high-pressure conditions over the British Isles, including Ireland. Cold air during winter and early spring mostly flows around ice-shielded Greenland. Therefore, it seems that stationary atmospheric circulation patterns during winter and spring 1740 significantly conditioned sea surface temperatures and marine boundaries along the European Atlantic coasts and also influenced the conditions over Ireland (Luterbacher et al., 2002). Briffa and Jones (2006) suggest also the development of a persistent, cold blocking high over central Europe, which reached unusually far west. This suggests that cyclonic activity was restricted to Iceland and parts of the Mediterranean regions.

While the spring of 1740 still remained slightly too dry, over the following seasons precipitation returned to normal levels. Still, temperatures remained too cold until spring 1741. In October 1740 the Dublin Gazette reported: “We hear

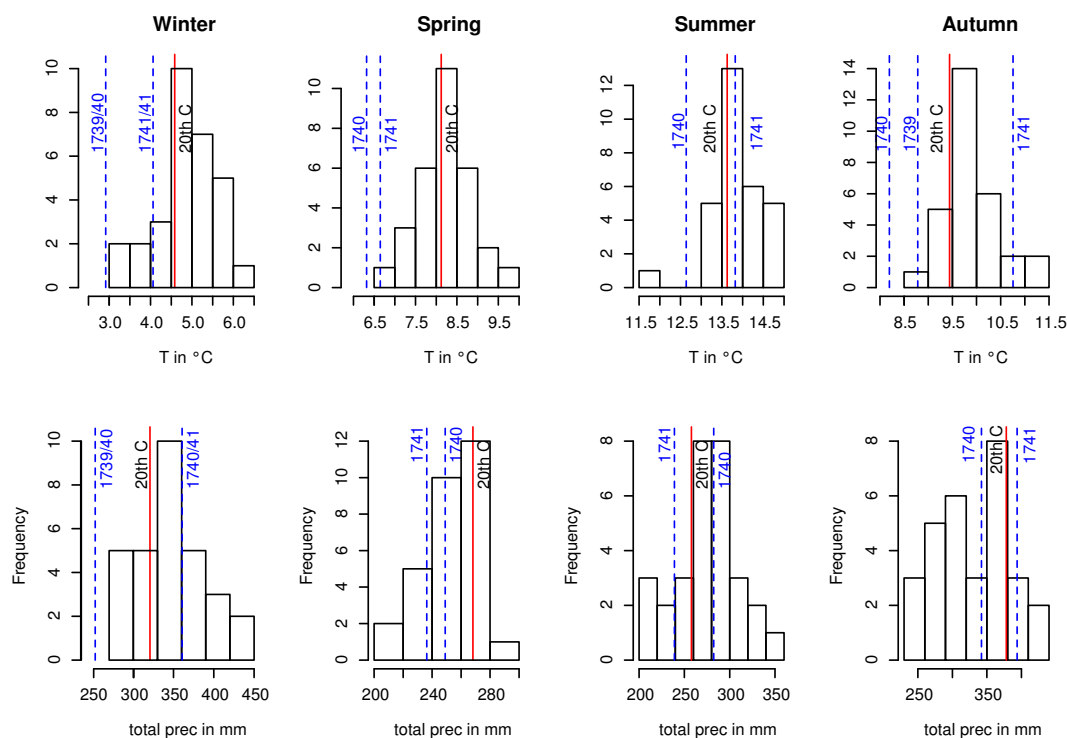


Fig. 3. Seasonal climate diagrams for Ireland (averaged over land only grid cells 51°N – 56°N , 11°W – 5°W). The histograms show temperatures (top panels) and seasonal precipitation (1710–1739). Solid red lines mark 1961–1990 averages; dashed blue lines denote values for seasons during the famine, years marked adjacent. Data from Luterbacher et al. (2000, 2004, 2007), Xoplaki et al. (2005) and Pauling et al. (2006).

from Belfast, that there has been for these several days last past, the coldest weather and the greatest fall of snow and sleet, that hath been known in that part of the world at this time of the year; the snow was so deep on the road between that place and Ballymena, that a person coming from thence with a horse, was in much danger of perishing, he often sunk out of sight in the snow and was oblig'd to turn back again" (The Dublin Gazette, 1740d).

4.3 Impacts and coping strategies

In the context of the FVAM the phase of coping capacity/strategies and direct impacts consists of consecutive feedback loops, which are characterised by consecutive responses to one another. This phase began after the climate, as the main initial driver, started to affect the socio-environmental system in Ireland. In 1739 the potato crop failed (Salaman, 1985; Smith, 1774a). With the failure of the potato, the prices of all edible goods on the markets increased. In April 1740 George Faulkner's *The Dublin Journal* noted: "There is now as great scarcity of provision in this city [Dublin] as ever known, and it is much to be feared all over this kingdom, every kind of food being at vast high prices, which is owing to the great drought we have had ever since last Christmas, there not having been one day's rain. During that time

forty thousand sheep have died in Connaught within these two months" (George Faulkner, *The Dublin Journal*, 1740a).

In September 1739, prior to the harvest failure, the price for one quarter of wheat was one pound and ten schillings. With the ongoing strong frost conditions and the failing potato crop, demand for wheat and other crops rose as well as the prices for these goods (Fig. 6). The drought that followed the winter frost in spring 1740 exacerbated the food shortage. At the peak of the famine, the price for one quarter of wheat was more than three pounds, almost three times the price paid in September 1739.

While Irish price statistics for oats, oatmeal, and potatoes are missing for 1740–1741, narrative sources indicate a drastic increase of prices for all of these goods. John Ruddy, a Quaker physician and naturalist from Dublin, noted in his weather diary (published in 1770, 2010) that after the potatoes had failed, "other provisions bore double or treble their usual price" in autumn 1740. The diary of the farmer Nicholas Peacock, who lived in the County of Limerick, also supports these reports on increasing price trends. He sold oats at a price of 14 shillings for one barrel and thus nearly twice as high as the average price of oats (8.7 shillings) of 1740–1748 (Legg, 2005). Other sources also report on the "extravagant price" of potatoes in Ireland (Dickson, 1997). While rising market prices do not directly reflect food availability

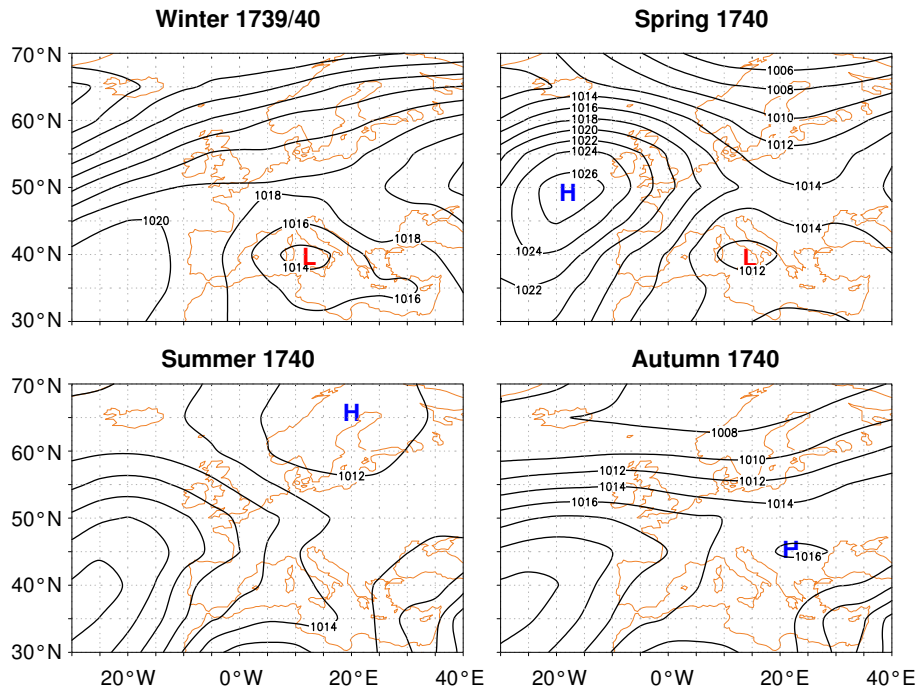


Fig. 4. Seasonal averages of sea level pressure in 1740. During spring a strong blocking high west of the British Isles led to cold air advection from the north. Data from Luterbacher et al. (2002).

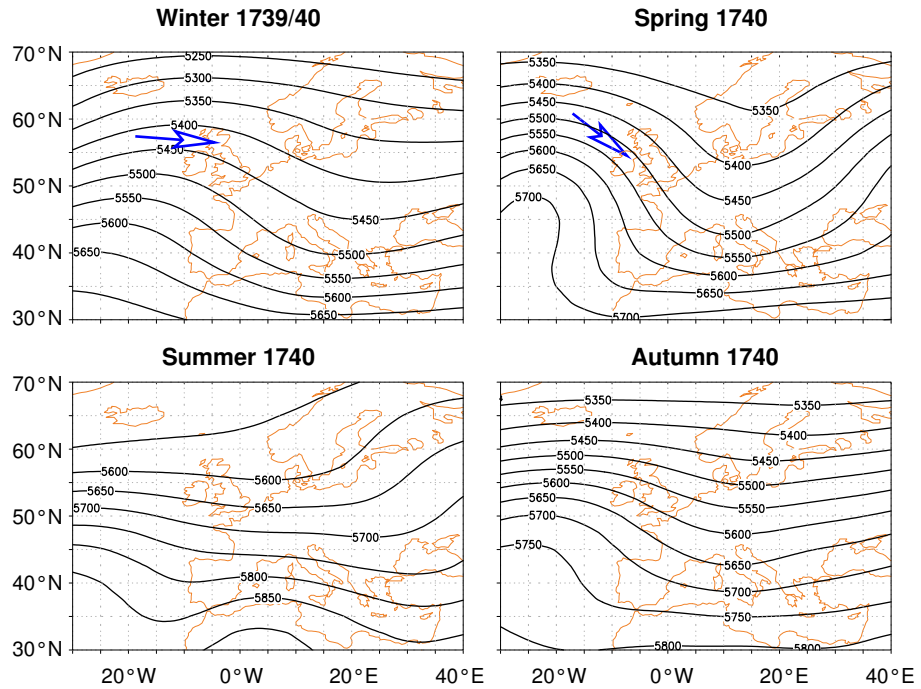


Fig. 5. Seasonal averages of geopotential height at 500 hPa during 1740. From a zonal flow during winter 1739–1740 (blue arrow) synoptic situation changed to meridional flow in spring, advecting cold air from the north. Data from Luterbacher et al. (2002).

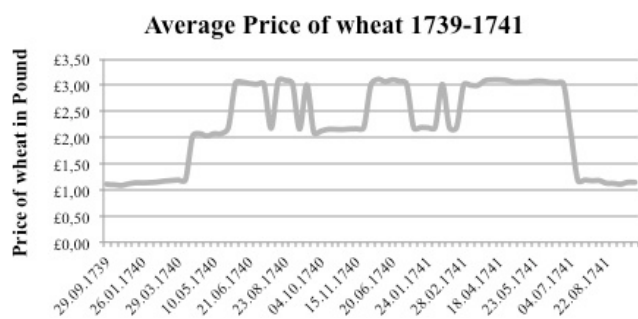


Fig. 6. Average price of wheat (one quarter=40 stone) (data: George Faulkner, *The Dublin Journal*, 1739–1741).

in an economy in which many people depended on self-subsistence, they do reflect the hardship suffered by those segments of the Irish society participating in food markets. As Post (1995) pointed out, “food and drink accounted for some 60–75 % of the household budgets of the labouring population when cereal prices stood at normal levels”. Increasing food prices thus severely affected the purchasing power of households.

Ireland was an export-oriented country for food products, but in times of crises this changed in certain economic sectors. For obvious reasons of supply, the exports of live cattle, oatmeal, etc. were cut drastically. Nevertheless, some important goods for nutrition were exported in high amounts, regardless of the scarce food situation, for example butter, beef, barley and malt (O’Brien, 1918). In 1740–1741, hake was also exported in large amounts. Some counties, such as Waterford, also spent shares of their money for luxury commodities such as tobacco, wine, etc. (Smith, 1774a).

In the course of the crisis, as a coping strategy, many poor changed their eating habits. These changes were two-fold: less and different. “Less” is obvious; “different” means that diets would include “famine foods” (Ó Gráda, 2009). Nutrient content became more important than taste. Even sour milk, nettles, charlock, and rotten potatoes were consumed (Dickson, 1997). Less and unhealthy food often harmed the immune system of individuals and made them more vulnerable to diseases. Not surprisingly, the death rate was greatest among the poor. George Faulkner’s, *The Dublin Journal* reported: “Here is an uncommon mortality among the poor people, by fevers and fluxes, owing, no doubt, in a great measure to their poor living” (George Faulkner, *The Dublin Journal*, 1740b). In March 1741, Ruddy (1770) noted in his diary how the “dysentery raged greatly” among the most exposed segments of the Dublin population. At its peak dysentery caused 21 deaths in a single week, “though it was less mortal than in the country”.

Besides “famine foods”, other forms of desperation occurred. Some Dubliners began rioting and looting: “Last Saturday in the evening, Sunday and yesterday, we had very great tumults, occasioned by the great dearth of bread,

meal, &c. Several bakers shops were broke open, and their goods sold at a low price to the poor; great damages have been done on this occasion, many persons being wounded and some killed” (George Faulkner, *The Dublin Journal*, 1740c).

Similar incidents occurred in other places. In his account of the famine, Dickson describes the “atmosphere in the towns” as “more explosive” (Dickson, 1997) than in the countryside. As food theft became more common, the number of prisoners rose and punishment for such crimes was aggravated. As a reaction to jails overcrowding in the kingdom of Ireland some of the prisoners were deported to North America (McDonnell, 1992). Clearly, these so-called “transportees” were forced migrants to the “New World”.

Alongside such measures, some private and public relief programs were established. The following charity actions were reported from the small town of Cashel, in County Tipperary: “Every Sunday, Tuesday and Thursday, they [the poor] are served with excellent soup well seasoned with spice and herbs, and thickened with oat meal; every other day, they have stirabout well prepared, for to every hogshead of water there is allowed half a barrel of meal, 12 pound of butter, a peck of salt, a quarter of a pound of pepper; each grown person, gets three pins at each mess, and every young body, half as much, which serves most of them for two good meals; this contribution is wholly confined to the town” (George Faulkner, *The Dublin Journal*, 1741).

In Dublin a hundred poor were fed for free at the university on a daily basis (George Faulkner, *The Dublin Journal*, 1740d). Furthermore, in the peak periods of the famine, the workhouse served around 34 000 poor in a week (George Faulkner, *The Dublin Journal*, 1740e). Huge problems were posed by increasing unemployment in the towns. As is typical for pre-industrial subsistence crises, at some point the famine turned into a general economic depression, which manifested in a diminished demand for labour (McCracken, 1986). Many Irishmen tried to escape unemployment through short-term labour migration. Most went to England to work as seasonal harvesters or to find work in big cities such as London.

The French economic historian Ernest Labrousse, in his seminal study of Ancient Regime-type crises, described the cyclical effects of food crises (Labrousse, 1933, 1944; Mauelshagen, 2010): Bad harvests led to general recessions causing mid-term effects on markets for non-agricultural products and labour markets: harvest failure caused higher food prices; higher food prices reduced the spending capacity of large parts of the population. Even in cities with good market networks, the relative expenses of citizens for basic supplies went up significantly, which meant they had less to spend on other products. As a result, the demand for manufactured products and services declined, reducing the income of employees in these sectors or even leading to unemployment. Labour markets were also directly affected by harvest failures due to declining demand for wage labourers in the

countryside. In Ireland, the lack of commercialised food markets and the relatively low level of market integration aggravated these impacts of food crises, which were effective more or less everywhere in pre-industrial Europe. Though the Irish labour markets were relatively stable before the famine – there were (nearly) no reports on problems with high unemployment rates prior to 1740 – they lacked resilience to Labrousse-type crises. Already shortly after the first impacts of the extreme climatic conditions began to appear, unemployment rates in the towns and in their hinterlands went up.

Even though coping strategies were activated, the fatality ratio was unusually high. Ó Gráda (2009) has estimated the mortality rate during the Great Frost of 1740–1741 at 13 %, compared with 12 % during the “Great Irish Famine” in the nineteenth century. The death ratio is not the only demographic effect similar to the Great Famine. According to some studies, the ratio of the population moving within Ireland or leaving the country during the famine of 1740–1741 was just as high as it was in 1845–1852 (see the following section on the adaptation phase).

4.4 Adaptation and migration

Adaptation in the aftermath of famine is the last phase considered by the FVAM, which structures our study. Generally, adaptive action may be taken on all levels of a society, and it may be targeted at mitigating any aspect of vulnerability paving the way for disaster (i.e. prevention), or at improving preparedness before it strikes again. Adaptability is a key to evaluating a society’s resilience. Societies are self-organised based on communication, and written forms or media of communication provide evidence of adaptive processes in past societies. After famines in early modern Europe, debates over preventive measures peaked with regularity. As in many other places in Europe and at different times, some observers of the Irish calamity in 1740–1741 asked for state granaries (Powell, 1757). Thomas Prior, founder of the Royal Dublin society, suggested: “The best course to guard against scarcity, is to encourage farmers to raise large quantities of corn yearly, that the redundancy of plentiful crops may be sufficient to answer the deficiencies of bad ones. And this can no other ways be done, than by affording them a constant and reasonable price for the quantities of corn they shall raise. [...] It will easily occur to every one, that granaries under proper regulations would answer all those intentions” (Prior, 1741).

As mentioned in Sect. 3, diseases such as smallpox, influenza, and severe fevers spread during the famine. Consequently, some cities started or improved their public health systems. For example the city of Cork, with the help of charitable members of the “Musical Society”, erected a medical facility in which ten physicians and four surgeons attended the poor three hours every day (Smith, 1774b, 390f pp.). “Some years above 2000” patients were treated in such facilities (Smith, 1774b, p. 391).

For the rest of this section on adaptation, our main focus will be on migration as a specific form of adaptation either during or immediately after the famine of 1740–1741. The reasons for this focus are partly contextual and partly historical. The contextual reason is that research for this study was carried out in the framework of the “Climates of Migration” project, which studies climate fluctuations as push factors involved in historical cases of migration. The historical reason is the outstanding role of migration in Ireland’s national history, which is more or less that of an unending demographic disaster following the onset of the Great Famine in 1845. Looking further back, into Ireland’s “pre-famine history”, sheds new light on the relation between famine and migration.

Before returning to our case study, we need to explain why we consider migration as a form of adaptation at all. The answer is neither obvious nor trivial. Some scholars have argued that people decide to leave home and move to other places only after their efforts to adapt to changing social or environmental conditions have failed. Others regard migration as “last-resort adaptation” (Stern, 2007). Both these views are sound and apply in some cases of migration. Yet, the assumptions underlying these conceptualisations are not self-evident. Regarding migration as adaptive failure emphasises people’s attachment to place and the local conditions of their livelihoods. However, this emphasis is biased in that it takes sedentary forms of society as the rule. From a historical perspective this is as doubtful as the idea that people choose to move only at the end of a chain of attempts to stay in place, which nurtures the expectation that the most vulnerable, or poorest, segments of a population are also most likely to move away.

Empirical studies unmask such generalisations as based on purely theoretical assumptions. Historians have unravelled such an enormous variety of forms of migration that it is difficult to make any generalisations. Nevertheless, we can state with some confidence that the costs of migration in the eighteenth century, particularly for permanent long-distance emigration, excluded migration as an option for the poorest among the poor. In times of famine, it was not migration, but the death of those who stayed “at home” even after “home” had been turned into a place of misery, which represent the real (and fatal) failure of all attempts to adapt. Furthermore, we must consider seasonal labour migration, which existed in several parts of early modern Europe. When the usual rhythm of these migrations was disturbed by climatic anomalies, some adaptive reaction was required (Lucassen, 1987). In sum, it is more appropriate to consider migration as a fairly common practice of adapting to socio-economic or environmental change, particularly during famine periods, no matter whether migration was permanent, temporary or circular, or whether it was long or short distance. Such a perspective is also more flexible, because it does not at all deprive us of recognising the limits of the adaptive capacities of people to

sustain their livelihoods under pressure in a certain place and at a certain time.

Though no precise totals can be given, demographers agree that the famine of 1740–1741 produced very high numbers of migrants. Fitzgerald and Lambkin give 1741 as a “migration landmark” (Fitzgerald and Lambkin, 2008, their Fig. 5). Smyth even states that the migration rate in 1741 was as high as during the Great Irish Famine of 1845–1852 (Smyth, 2006 cited in Fitzgerald and Lambkin, 2008). However, his estimates may be too high and cannot be verified. People’s movements during the crisis were mostly internal; but also very substantial emigration (external migration) occurred in 1740–1741 (Dickson, 1997).

Generally, the predominant pattern of internal migration was from rural to urban areas. Seeking work and food, people moving away from the countryside hoped to escape calamitous conditions and survive in the framework of nearby towns and cities (Ó Dálaigh, 1995). As regards emigration, different groups of emigrants from Ireland must be distinguished, the so-called Ulster-Scots or Scotch-Irish from the northern parts of Ireland, Protestants and Presbyterians (Fitzgerald and Lambkin, 2008; Dickson, 1997; Cullen, 1981; Wokeck, 1989, 2003; O’Brien, 1918; Stevenson, 1920). The path taken by many led to the New England colonies and Pennsylvania, with which trade connections with Ireland existed (George Faulkner, *The Dublin Journal*, 1729; *The Dublin Gazette*, 1740e). A great number of Irish immigrated to Philadelphia, often following the paths of their relatives and friends who had migrated in 1728–1729 (chain migration). Wokeck (1989) found out that the immigration rate to Philadelphia (Pennsylvania) rose by 500% from 1730 to 1740. In 1740 and 1741 the migrants from Southern Ireland to the Delaware Valley also increased drastically by around 300–400% (Wokeck, 2003). In the North of Ireland, “the emigrants leaving Belfast and Derry for America were no fewer than twelve thousand annually” during the famine (Stevenson, 1920). The emigration rate in the famine of 1740–1741 could have been even greater, but “mostly Irishmen [were] too poor to pay for the transatlantic passage” (Wokeck, 1989).

Of course, migration in 1740–1741 must be seen in the wider context of Irish population movements preceding or following these famine years. The demographic background of all Irish migrations before the nineteenth century – as is the case with almost all European migrations – is rather obscure (Cullen, 1994): full demographic statistics documenting in and outmigration per country over decades or centuries do not exist before 1800; moreover, the Irish case is particularly complicated in the eighteenth century, when inflows paralleled outflows (a pattern resembling the Netherlands in the same period). In fact, inflows and outflows were interconnected in a sense that immigration nurtured emigration, particularly in the case of Ulster. Moreover, Cullen (1994) has pointed out that Irish emigration during the seventeenth and eighteenth centuries “was especially complex because it

flowed in so many different directions”, to continental North America, the Amazon basin, the West Indies, and to Europe. The forces behind Irish mobility were a “mix of elements of dynamism, persecution, and poverty” (Cullen, 1994).

Our study of the 1740–1741 famine questions whether the complex interplay between socio-economic and natural forces, notably climate extremes, can be grasped in purely economic categories such as “poverty”. While poverty is a static category entrenched in socio-economic structure, its interrelations with agro-meteorological risks coming from the occurrence of climatic extremes may be better suited to describe some of the characteristic dynamics fostering Irish migration in the first half of the eighteenth century. Where statistical information or reliable estimates are available, e.g. numbers drawn from passenger lists of vessels that crossed the Atlantic to North America, the peaks of Irish migration and their coincidence with climatic extremes are striking. For example, the peaks of Scotch-Irish immigration to North America in the eighteenth century occurred in 1717–1718, 1725–1729, 1740–1741, 1754–1755, and 1771–1775. All these peaks coincide with some of the harshest weather conditions.

Therefore, finally we raise the question of whether Irish migration in the context of the events of 1740–1741 may – or even should – be regarded as a case of climate migration. The term “climate migration” has emerged from recent debates over the probable and expectable consequences of global climate change, in which context it has provoked some controversy (Pigué et al., 2011). Many social scientists (including historians) simply consider migration too complex a problem to be explained by climatic fluctuations and reject outright the idea of climate migration as purely deterministic. Though some studies with backgrounds in the physical sciences nurture such scepticism by neglecting the social context, refusing the term “climate migration” for its (supposedly) inherent mono-causal reductionism is a misconception. Failure to name the multidimensionality of migration in a single word (or attribute) is not a feature specific to that term. “Labour”, “military”, or “chain migration”, like many other categories from the typologies of migration, could be rejected for the same failure; but they are not, because they are never misunderstood as attempts at explaining migration mono-causally. Rather than essentialist concepts, those terms represent a variety of research perspectives on migration as a social phenomenon.

The same is true for climate-induced migration. Here, we use this term for people’s movements following the economic and social impacts of climatic extreme events, often indicated by peaks in numbers of migrating people. Climatic extremes are defined as unusual anomalies deviating from fluctuations that are typical for the “normal” climate in a certain place, to which people are adapted. Whether these anomalies can be described as an element of climate change, is another question. Cold spells may have been typical of the Little Ice Age (LIA). However, periodization, characteristics, and local

characteristics of climate change during the LIA are still a matter of debate. The record of extremes is statistically insufficient to allow attribution of a single extreme event to LIA climate change. Thus, we distinguish between the terms “climate migration” and “climate change migration”. The latter term has been a matter of debate recently, as mass migration is for many an expected consequence of global warming (e.g. El Hinnawi, 1985; Perch-Nielsen et al., 2008; McLeman and Smit, 2006). Still, it does not easily apply to historical contexts, nor does the term “forced migration” that has been connected with climate change migration. Historical examples, such as the famine of 1740–1741, show that in the aftermath of climate-induced famines migration was a choice often taken voluntarily among alternative forms of adaptation. Though there may be examples where people believed they did not have a choice, it would be wrong to call climate migration “forced” simply by definition.

Therefore, we do indeed consider the peak of migrations during the Irish famine of 1740–1741 a case of climate migration. Our use of the term does not imply that socio-economic factors are negligible in contrast to the severity of the impacts of unusual climatic extremes. Rather on the contrary: only concrete socio-economic circumstances may explain the magnitude of those impacts. This is the whole point of combining a complex study of vulnerability (the FVAM) with climate reconstructions, as we did in this study.

5 Conclusions

In 1740–1741 extremely cold temperatures struck vast areas of pre-industrial Europe, causing harvest failures that led to increased prices for staple food, famine, disease, excess mortality and migration. Our case study focused on Ireland. Using a multi-indicator (or multi-variable) model for the analysis of famine vulnerability, the FVAM, we proved that Ireland was highly vulnerable to subsistence crises and famine when hit by climate extremes in 1740. Though our study was not comparative in the sense that we compared Ireland with one or more other countries, our assessment of the indicators of famine vulnerability included comparative aspects and, thus, allows us to hypothesise that Ireland was probably more vulnerable than most other European countries. Already in the first half of the eighteenth century, Irish food production was based heavily on potatoes and oats – a pattern of cultivation providing little resilience against the risk of harvest failure after an extremely cold winter. Irish landowners showed little effort to transform agriculture as they did in other parts of early-Enlightenment Europe. Excess growth had made the situation for the Irish population all the more precarious. Moreover, Ireland was ill-prepared to deal with the consequences of harvest failure: public or private relief could not count on granaries or health care. Involvement in war (with Spain), religious conflicts, and the exclusion of the Catholic majority from political participation likewise affected food

entitlements of large parts of the population. As a result, Ireland experienced excess mortality and (out-)migration higher than almost anywhere else in Europe. Though exact numbers are missing, the ratios are likely to resemble those during the Great Famine of 1845–1852. Finally, we have argued why the term “climate(-induced) migration” applies to Irish migration that occurred in the context of the events of 1740–1741.

Irish “pre-famine” famine history, i.e. the history of famines before the Great Famine of 1845–1852, has been somewhat neglected. With our study we seek to inspire further research on the same subject, which will help to put the Great Famine and Irish emigration in its aftermath into perspective. On a general (or theoretical) level, we claim that our study

1. provides a model analysis that integrates social vulnerability and climatic factors in the investigation of famines occurring in societies with economies dominated by the primary sector (agriculture);
2. integrates theories of declines in both food entitlements and food availability. The FVAM, applied in this study, is a flexible model that considers food entitlement and availability and their interconnectedness. Future analyses applying the FVAM to historical as well as recent cases of famine, and using the FVAM as a tool for comparison, will show whether the indicator system and the assessment of indicators require reconsideration;
3. offers a discussion of “climate migration” that makes the term applicable to historical cases and contexts avoiding, at the same time, any deterministic implications.

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References

- Abel, W.: Massenarmut und Hungerkrisen im vorindustriellen Europa, Versuch einer Synopsis, Verlag Paul Parey, Hamburg, Berlin, 1974.
- Akenson, D. H.: The Irish education experiment: The national system of education in the nineteenth century, Routledge & Kegan Paul/University of Toronto Press, London, Toronto, 1970.
- Benz, A., Lütz, S., Schimank, U., and Simonis, G.: Handbuch Governance. Theoretische Grundlagen und empirische Anwendungsfelder, Verlag für Sozialwissenschaften, Wiesbaden, 2007.
- Birkmann, J.: Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions, in: Measuring vulnerability to natural hazards, edited by: Birkmann, J., Towards disaster resilient societies, Tokyo, New York, Paris, 9–54, 2006.
- Blaikie, P. M., Connon, T., Davis, J., and Wisner, B. (Eds.): At risk: Natural hazards, people’s vulnerability, and disasters, Routledge, London, 1994.
- Bohle, H.-G.: Vulnerability and criticality: perspectives from social geography, IHDP Update, Newsletter of the International Human Dimensions Programme on Global Environmental Change, 1–7, 2001.
- Briffa, K. R. and Jones, P. D.: Unusual climate in northwest Europe during the period 1730 to 1745 based on instrumental and documentary data, *Climatic Change*, 79, 361–379, 2006.
- Clarkson, L. A.: Irish population revisited, 1687–1821, in: Irish population, economy, and society: Essays in honour of the late K. H. Connell, edited by: Goldstrom, J. M. and Clarkson, L. A., Oxford University Press, Oxford, New York, 14–18, 1981.
- Collet, D.: “Vulnerabilität” als Brückenkonzept der Hungerforschung, in: Handeln in Hungerkrisen, Neue Perspektiven auf soziale und klimatische Vulnerabilität, edited by: Collet, D., Schanbacher, A., and Lassen, T., Universitätsverlag Göttingen, Göttingen, 13–25, 2012.
- Connell, K. H.: The population of Ireland, 1750–1845, Clarendon Press, Oxford, 1950.
- Crawford, M. E.: William Wilde’s Table of Irish Famines, 900–1850, in: Famine: The Irish Experience 900–1900, Subsistence Crises and Famines in Ireland, edited by: Crawford, M. E., John Donald Publisher Ltd., Edinburgh, 1–30, 1993.
- Cruise O’Brien, M. and Cruise O’Brien, C.: Ireland, a concise history, Thames & Hudson, London, Singapore, 1985.
- Cullen, L. M.: The emergence of modern Ireland, 1600–1900, Batsford, London, 1981.
- Cullen, L. M.: The Irish diaspora of the seventeenth and eighteenth centuries, in: Europeans on the move: studies on European migration, 1500–1800, edited by: Canny, N. P., Clarendon Press, Oxford University Press, Oxford, New York, 1994.
- Cutter, S. L.: Vulnerability to environmental hazards, *Prog. Human Geogr.*, 20, 529–539, 1996.
- Daultrey, S., Dickson, D., and Ó Gráda, C.: Eighteenth-century Irish population: New Perspectives from Old Sources, *J. Econom. Hist.*, 41, 601–628, 1981.
- Delaney, D. R. and McCutcheon, W. A.: Irish canals, c. 1890, in: A new history of Ireland, Vol. IX, Maps, Genealogies, Lists, edited by: Moody, T. W., Martin, F. X., and Byrne, F. J., Oxford University Press, Oxford, 1984.
- Dickson, D.: Arctic Ireland: the extraordinary story of the great frost and forgotten famine of 1740–41, Belfast, 1997.
- Dickson, D., Ó Gráda, C., and Daultrey, S.: Hearth tax, household size and Irish population change, 1672–1821, *P. Roy. Irish Acad.*, 82C, 125–181, 1982.
- El Hinnawi, E.: Environmental refugees, United Nations Environmental Programme, Nairobi, 1985.
- Engler, S.: Developing a historically based Famine Vulnerability Analysis Model (FVAM) – An interdisciplinary approach, *Erdkunde – Archive for Scientific Geography*, 66, 157–172, 2012a.
- Engler, S.: Hungersnot – Bekannte Theorien und neue Analysemodelle, in: Handeln in Hungerkrisen, Neue Perspektiven auf soziale und klimatische Vulnerabilität, edited by: Collet, D., Schanbacher, A., and Lassen, T., Universitätsverlag Göttingen, Göttingen, 67–83, 2012b.
- Fallon, P. K.: Printing, literacy, and education in eighteenth-century Ireland: Why the Irish speak English, The Edwin Mellen Press, Lewiston, 2005.
- FAO: Education for rural people and food security, A cross-country analysis, <http://www.fao.org/docrep/010/a1434e/a1434e00.htm> (last access: 1 November 2012), 2005.
- FAO: Education and training for food security, Capacity building and good practices in five African countries, <http://www.fao.org> (last access: 20 June 2012), 2007.
- Febvre, L.: A geographical introduction to history (engl. translation from the French original “La terre et l’évolution humaine, Introduction géographique à l’histoire”, first published in Paris, 1922), Routledge & Paul Kegan, London, 1924.
- Feed the Future: Fact Sheet: Horn of Africa food crisis, <http://www.feedthefuture.gov/>, last access: 19 October 2011.
- Fitzgerald, P. and Lambkin, B.: Migration in Irish History, 1607–2007, Palgrave, Basingstoke, 2008.
- Fogel, R. W.: Second thoughts on the European escape from hunger, famines, chronic malnutrition, and mortality rates., in: Nutrition and poverty, edited by: Osmani, S. R., Oxford University Press, Oxford, New York, 243–286, 1992.
- Fogel, R. W.: The escape from hunger and premature death, 1700–2100, Europe, America, and the Third World, Cambridge University Press, Cambridge, 2004.
- Füssel, H. M.: Vulnerability: a generally applicable conceptual framework for climate change research, *Global Environ. Change*, 17, 155–167, 2007.
- George Faulkner, The Dublin Journal: Newspaper section: For the City of Philadelphia in Pensilvania [sic], Microfilm material of the National Library of Ireland, 14–17 June 1729, Dublin, 1729.
- George Faulkner, The Dublin Journal: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 12–15 April 1740, Dublin, 1740a.
- George Faulkner, The Dublin Journal: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 6–9 December 1740, Dublin, 1740b.
- George Faulkner, The Dublin Journal: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 31 May–3 June 1740, Dublin, 1740c.
- George Faulkner, The Dublin Journal: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 30 December 1740–3 January 1741, Dublin, 1740d.
- George Faulkner, The Dublin Journal: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 24–27 January 1740, Dublin, 1740e.

- George Faulkner, The Dublin Journal: Newspaper section: The following is an extract of a private letter from Cashel, May 18, Microfilm material of the National Library of Ireland, 19–23 May 1741, Dublin, 1741.
- Goodale, C. L., Aber, J. D., and Ollinger, S. V.: Mapping monthly precipitation, temperature, and solar radiation for Ireland with polynomial regression and a digital elevation model, *Clim. Res.*, 10, 35–49, 1998.
- Harvey, B.: Evolution of Health Services and Health Policy in Ireland, Dublin, http://www.cpa.ie/publications/EvolutionOfHealthServicesAndHealthPolicyInIreland_2007.pdf (last access: 12 March 2012), 2007.
- IPCC: Managing the risks of extreme events and disasters to advance climate change adaptation, Special report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, 2012.
- Kennedy, L. and Clarkson, L. A.: Birth, death and exile: Irish population history, 1700–1921, in: An historical geography of Ireland, edited by: Graham, B. J. and Proudfoot, L. J., Academic Press, London, 158–177, 1993.
- Kinealy, C.: This great calamity, The Irish famine, 1845–52, Gill & Macmillan, Dublin, 2006.
- Labrousse, E.: Esquisse du mouvement des prix et des revenus en France au XVIII^e siècle, Dalloz, Paris, 1933.
- Labrousse, E.: La crise de l'économie française à la fin de l'Ancien Régime et au début de la Révolution, Presses Universitaires de France, Paris, 1944.
- Lecky, W. E. H.: A history of Ireland in the eighteenth century, Vol. 1, Longmans Green and Co., London, 1913.
- Legg, M.-L.: The diary of Nicholas Peacock, The worlds of a County Limerick farmer and agent, Four Courts Press, Dublin, 2005.
- Lucassen, J. M. W. G.: Migrant labour in Europe, 1600–1900: The drift to the North Sea, Croom Helm, London, Sydney, Wolfeboro, 1987.
- Luterbacher, J., Rickli, R., Tinguely, C., Xoplaki, E., Schüpbach, E., Dietrich, D., Hüsler, J., Ambühl, M., Pfister, C., Beeli, P., Dietrich, U., Dannecker, A., Davies, T. D., Jones, P. D., Slonosky, V., Ogilvie, A. E. J., Maheras, P., Kolyva-Machera, F., Martin-Vide, J., Barriendos, M., Alcoforado, M. J., Nunez, F., Jónsson, T., Glaser, R., Jacobeit, J., Beck, C., Philipp, A., Beyer, U., Kaas, E., Schmith, T., Bärring, L., Jónsson, P., Rácz, L., and Wanner, H.: Reconstruction of monthly mean sea level pressure over Europe for the Late Maunder Minimum period (1675–1715), *Int. J. Climatol.*, 20, 1049–1066, 2000.
- Luterbacher, J., Xoplaki, E., Dietrich, D., Rickli, R., Jacobeit, J., Beck, C., Gyalistras, D., Schmutz, C., and Wanner, H.: Reconstruction of Sea Level Pressure fields over the Eastern North Atlantic and Europe back to 1500, *Clim. Dynam.*, 18, 545–561, 2002.
- Luterbacher, J., Dietrich, D., Xoplaki, E., Grosjean, M., and Wanner, H.: European seasonal and annual temperature variability, trends, and extremes since 1500, *Science*, 303, 1499–1503, doi:10.1126/science.1093877, 2004.
- Luterbacher, J., Liniger, M. A., Menzel, A., Estrella, N., Della-Marta, P. M., Pfister, C., Rutishauser, T., and Xoplaki, E.: The exceptional European warmth of Autumn 2006 and Winter 2007: Historical context, the underlying dynamics and its phenological impacts, *Geophys. Res. Lett.*, 34, L12704, doi:10.1029/2007GL029951, 2007.
- Magennis, E.: The Irish political system, 1740–1765, The golden age of the undertakers, Four Courts Press, Dublin, 2000.
- Mauelshagen, F.: Klimageschichte der Neuzeit, 1500–1900., WBG, Darmstadt, 2010.
- McCracken, J. L.: The social structure and social life, 1714–60, in: A new history of Ireland, IV Eighteenth-century Ireland, 1691–1800, edited by: Moody, T. W. and Vaughan, W. E., Oxford University Press, Oxford, 31–56, 1986.
- McDonnell, F.: Emigrants from Ireland to America, 1735–1743, Bentley Enterprises, Baltimore, 1992.
- McLeman, R. and Smit, B.: Migration as an adaptation to climate change, *Climatic Change*, 76, 31–53, 2006.
- O'Brien, G. A. T.: The economic history of Ireland in the eighteenth century, Nabu Press (reprint), Dublin, London, 1918.
- Ó Dálaigh, B.: Ennis in the 18th century, Portrait of an Urban Community, Irish Academic Press, Dublin, 1995.
- Ó Gráda, C.: Irish agricultural history: recent research, *Agr. Hist. Rev.*, 38, 165–173, 1990.
- Ó Gráda, C.: Famine, a short history, Princeton University Press, Princeton, 2009.
- Oliver-Smith, A.: Peru's five hundred year earthquake: vulnerability in historical context, in: Disasters, development and environment, edited by: Varley, A., J. Wiley, Chichester, New York, 3–48, 1994.
- Oliver-Smith, A.: Theorizing Vulnerability in a globalized world. A political ecological perspective, in: Mapping vulnerability: disasters, development and people, edited by: Bankoff, G., Frerks, G., and Hilhorst, D., Earthscan, London, 10–24, 2004.
- Pahs, R.: Regionalentwicklung zwischen lokalen und transnationalen Systemen: Ein multiperspektivischer Ansatz am Beispiel der Western Province, Zambia, Dissertation zur Erlangung des Doktorgrades, Bochum, 2006.
- Pauling, A., Luterbacher, J., Casty, C., and Wanner, H.: 500 years of gridded high-resolution precipitation reconstructions over Europe and the connection to large-scale circulation, *Clim. Dynam.*, 26, 387–405, doi:10.1007/s00382-005-0090-8, 2006.
- Perch-Nielsen, S., Battig, M., and Imboden, D.: Exploring the link between climate change and migration, *Climatic Change*, 91, 375–393, 2008.
- Persson, K. G.: Grain markets in Europe, 1500–1900, Integration and deregulation, Cambridge University Press, Cambridge, 1999.
- Pfister, C. and Brázdil, R.: Social vulnerability to climate in the “Little Ice Age”: an example from Central Europe in the early 1770s, *Clim. Past*, 2, 115–129, doi:10.5194/cp-2-115-2006, 2006.
- Piguet, E., Pécoud, A., and de Guchteneire, P. (Eds.): Migration and climate change, Cambridge University Press, Cambridge, 2011.
- Post, J. D.: Climatic variability and the European mortality wave of the early 1740s, *J. Interdiscipl. Hist.*, 15, 1–30, 1984.
- Post, J. D.: Nutritional status and mortality in eighteenth-century Europe, in: Hunger in history. Food shortage, poverty, and deprivation, edited by: Newman, L. F., Cambridge, Oxford, 241–280, 1995.
- Powell, S.: A proposal for lessening the excessive price of bread corn in Ireland, Dublin, 1757.
- Pringle, D. G.: Irish Health Services (1), Lecture material of the National University of Ireland, Maynooth, <http://www.nuim.ie/staff/dpringle/courses/amg/hs01.pdf>, last access: 12 March 2012.

- Prior, T.: A proposal for erecting granaries in the city of Dublin, and other parts of the kingdom, to prevent any scarcity of corn for the future, Archival material of the National Library of Ireland, call number: P 2317 (6), Dullin [sic], 1741.
- Proudfoot, L. J.: Spatial transformation and social agency: Property, society and improvement, c. 1700 to c. 1900, in: *An historical geography of Ireland*, edited by: Graham, B. J. and Proudfoot, L. J., Academic Press, London, 219–257, 1993.
- Reilly, J. M.: Climate Change and Agriculture: The State of the Scientific Knowledge, *Climatic Change*, 43, 645–650, 1999.
- Rötter, R. and Van de Geijn, S. C.: Climate Change Effects on Plant Growth, Crop Yield and Livestock, *Climatic Change*, 43, 651–681, 1999.
- Rutty, J.: A chronological history of the weather and seasons, and the prevailing diseases in Dublin: with the various periods, successions, and revolutions, during the space of forty years: with a comparative view of the difference of the Irish climate and dise, Reprinted 2010, Milton Keynes, 1770.
- Salaman, R.: The history and social influence of the potato, Cambridge University Press, Cambridge, 1985.
- Schellekens, J.: Irish famines and English mortality in the eighteenth century, *J. Interdiscipl. Hist.*, 27, 29–42, 1996.
- Sen, A.: Poverty and famines. An essay on entitlement and deprivation, Oxford University Press, Oxford, 1981.
- Sen, A.: Resources, values and development, Oxford University Press, Oxford, 1984.
- Smerdon, J. E., Kaplan, A., Chang, D., and Evans, M. N.: A pseudoproxy evaluation of the CCA and RegEM methods for reconstructing climate fields of the last Millennium, *J. Climate*, 24, 1284–1309, doi:10.1175/2010JCLI4110.1, 2011.
- Smith, C.: The ancient and present state of the county and city of Waterford, Containing a natural, civil, ecclesiastical, historical and topographical description thereof, 2nd Edn., Archival material of the National Library of Ireland, Dublin, 1774a.
- Smith, C.: The ancient and present state of the county and city of Cork, Containing a natural, civil, ecclesiastical, historical and topographical description thereof, 2nd Edn., Archival material of the National Library of Ireland, Dublin, 1774b.
- Smyth, W. J.: Map-making, Landscapes and memory: A geography of colonial and Early Modern Ireland c. 1530–1750, Cork University Press, Cork, 2006.
- Stephens, D.: Thoughts of present concernment, for the relief of the poor in a scarcity of Corn, Archival material of the National Library of Ireland, call number: JP.1541, Dublin, 1746.
- Stern, N.: The economics of climate change, The Stern Review, Cambridge University Press, Cambridge, 2007.
- Stevenson, J.: Two Centuries of Life in Down 1600–1800, The Linenhall Press, Belfast, 1920.
- The Belfast News Letter: Newspaper section: Belfast, Microfilm material of the Linenhall Library of Belfast, 8 February 1740, Belfast, 1740.
- The Dublin Gazette: Newspaper section: Dublin, January 1, Microfilm material of the National Library of Ireland, 29 December 1739–1 January 1740, Dublin, 1740a.
- The Dublin Gazette: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 19–22 April 1740, Dublin, 1740b.
- The Dublin Gazette: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 5–8 January 1740, Dublin, 1740c.
- The Dublin Gazette: Newspaper section: Dublin, Microfilm material of the National Library of Ireland, 25–28 October 1740, Dublin, 1740d.
- The Dublin Gazette: Newspaper section: Dublin, June 21, Microfilm material of the National Library of Ireland, 17–21 June 1740, Dublin, 1740e.
- Turner II, B. L., Kasperson, R. E., Maston, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., and Schiller, A.: A framework for vulnerability analysis in sustainability science, *P. Natl. Acad. Sci.*, 100, 8074–8079, 2003.
- Walker, B., Holling, C. S., Carpenter, S. R., and Kinzig, A.: Resilience, adaptability and transformability in social-ecological systems, *Ecol. Soc.*, 9, <http://www.ecologyandsociety.org/vol9/iss2/art5/> (last access: May 2013), 2004.
- Werner, J. P., Luterbacher, J., and Smerdon, J. E.: A pseudoproxy evaluation of Bayesian hierarchical modelling and canonical correlation analysis for climate field reconstructions over Europe, *J. Climate*, 26, 851–867, doi:10.1175/JCLI-D-12-00016.1, 2013.
- Wisner, B., Blaikie, P., Cannon, T., and Davis, I.: At risk. Natural hazards, people’s vulnerability and disasters, 2nd Edn., Routledge, London, New York, 2004.
- Wokeck, M. S.: German and Irish Immigration to Colonial Philadelphia. In: *Proceedings of the American Philosophical Society*, 133, 2, Symposium on the Demographic History of the Philadelphia Region, 1600–1800, 128–143, 1989.
- Wokeck, M. S.: Trade in strangers. The beginnings of mass migration to North America, Pennsylvania State University Press, Pennsylvania, 2003.
- Xoplaki, E., Maheras, P., and Luterbacher, J.: Variability of climate in meridional Balkans during the periods 1675–1715 and 1780–1830 and its impact on human life, *Climatic Change*, 48, 581–614, 2001.
- Xoplaki, E., Luterbacher, J., Paeth, H., Dietrich, D., Steiner, N., Grosjean, M., and Wanner, H.: European spring and autumn temperature variability and change of extremes over the last half millennium, *Geophys. Res. Lett.*, 32, L15713, doi:10.1029/2005GL023424, 2005.