Adapting flood preparedness tools to changing flood risk conditions: the situation in Poland*

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Abstract

Flooding is the most destructive natural hazard in the Baltic Sea Basin in general and in Poland in particular. The notion includes floods from rivers and mountain torrents, as well as floods from sea surges in coastal areas, and floods from sewage systems. There have been several large floods in Poland in the last century and in recent decades, with damage exceeding 1% of the Polish GDP. The spatial and temporal characteristics of the flood risk in Poland are reviewed and observations and projections of changes in the flood hazard in the country are discussed. Furthermore, flood defences and flood preparedness systems in Poland are examined, with particular reference to the European Union (EU) Floods

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Directive, which is being implemented in Poland, an EU country. Finally, the public debate on flood risk and flood preparedness is reviewed.

1. Introduction – flooding in Poland

As defined in the EU Floods Directive (CEC 2007), the term 'flood' means 'the temporary covering by water of land not normally covered by water'. The notion includes floods from rivers and mountain torrents, as well as floods from sea surges in coastal areas. In some interpretations, it also includes floods from sewage systems.

Flooding is the most destructive natural hazard in the Baltic Sea Basin in general and in Poland in particular. Most of Poland is located in the drainage basins of two large rivers: the Vistula (whose drainage basin covers 54% of the country's area) and the Odra (34%). Both have their sources in mountain areas and empty into the Baltic Sea. Many towns and large cities are situated on the two rivers and their tributaries. Flood risk and flood preparedness became matters of broad concern, following the dramatic inundations in Poland in 1997 and 2010, during which the number of fatalities exceeded 55 and 20 respectively. National flood losses were estimated to reach billions of euros and made headline news. In 1980, 1997 and 2010 flood damage reached or exceeded 1% of the Polish GDP. Floods have also caused serious social damage: the ill health of inhabitants, stress, social disruption, and losses to the natural and cultural environments.

There are several interfaces of the contents of this paper with marine sciences. One obvious interface is the mechanism of storm surges, which originate at sea and affect coastal areas. On the other hand, the influx of masses of polluted flood water from rivers to the Baltic Sea affects sea water quality. During a flood, sewage treatment plants are inundated and agricultural chemicals are flushed in the surface runoff to rivers and their recipients, such as the Baltic Sea.

2. Spatio-temporal characteristics of flood risk in Poland

There have been several large floods in Poland in the last hundred years. A destructive flood occurred in the basin of the Vistula in July 1934, killing 55 people, inundating 1260 km^2 of land and destroying 78 bridges and 22 000 buildings (Cyberski et al. 2006). Between 1946 and 2010, 16 large floods of regional extent occurred in Poland (Kundzewicz et al. 2012). Abundant rainfall was the most frequent cause of floods, in seven years: 1960, 1970, 1977, 1980, 1997, 2001, 2010. Floods caused by storm surges occurred in five years: 1983, 1988, 1993, 1995, 2001. Ice-jam floods occurred in 1947 and 1982, while there was a snowmelt flood in 1979 and a snowmelt-cum-rainfall flood in 2001. The floods of 1960, 1979, 1980, 1997, 2001 and 2010 affected several regions. Some floods, such as the event in May 2010, also affected coastal waters (cf. Zajączkowski et al. 2010).

After record levels of snow cover in most of Poland during the winter of 1978/1979, a large snowmelt flood evolved in March and April 1979, called the 'flood of small rivers', which inundated 1000 km^2 of farmland and destroyed 1250 bridges. The wet summer of 1980 resulted in a large-scale flood all over the country, destroying 3300 bridges. In January 1982, an ice-jam flood on the Vistula upstream of the Włocławek reservoir inundated a land area of 100 km^2. The two largest floods in the Third Republic of Poland (since 1989) occurred in 1997 and 2010, as mentioned in the Introduction.

Rainfall floods can occur on all rivers in the country. The flood risk is the highest in the headwaters of the Vistula and the Odra and their mountain and piedmont tributaries. Sometimes intense and/or long-lasting rainfall and snowmelt occur simultaneously, producing a mixed-mechanism flood, as has happened on large lowland rivers (Narew, Bug, Warta, Noteć).

The areas in Poland subject to the greatest river flood risk lie to the south of latitude 51°N: the Carpathians, the southern part of the Sudeten Mountains, and the central part of the Bug river basin (Kundzewicz et al. 2012). Typically, the two periods of high river flow in Poland are in spring (with snowmelt and ice melt) and summer (with intense precipitation). Floods caused by advective and frontal precipitation covering large areas are typical in most of the Upper Vistula river basin. Most severe floods, in terms of flood fatalities and material damage, have occurred in large river valleys and particularly in urban areas protected by embankments. When a very large flood comes, the dykes may fail to withstand the masses of water and break, so that adjacent areas with high damage potential are inundated.

The highest flood hazard can be expected in the following multiple-risk situations:

– a flood wave on a tributary coincides with a flood wave on the main river. In this context, especially dangerous locations are the confluence of the River Nysa Kłodzka with the Odra, the confluence of the River Warta with the Odra, and the confluences of the Dunajec, San and Narew with the Vistula;

– intense rainfall during snow melting (on the lowlands);

– intense rainfall in urban areas during the passage of a flood wave on a river.

Storm surges occur along the whole coast of Poland, and their magnitude depends on a range of factors, one being the sea level (Wiśniewski & Wolski

2011). Poland's Baltic Sea coastline consists predominantly of sandy, barrier beaches, dunes and cliffs, and populated coastal lowlands. The coast can be split into three parts, reflecting major differences in physiographic and economic features – from west to east: (i) the Odra Estuary (including the conurbations of Szczecin and Świnoujście), (ii) the western and central-eastern dunes, cliffs, and the open sea barrier beaches (including the Hel Peninsula); and (iii) the Vistula Delta (with the conurbations of Gdańsk and Elbląg, with similar physiographic features), including Gdynia and Sopot. Pruszak & Zawadzka (2008) point out that the socioeconomic vulnerability of the Polish coast (without considering adaptive measures) is particularly high in the eastern and western parts, of enormous industrial, economic and social importance, where large towns are located near the main areas of potential flooding: the lagoons and lowlands of the Vistula and Odra deltas. Also, the ports of Świnoujście and Ustka, of considerable national importance, are situated in sensitive areas. Further, ecosystems in the central regions of the Polish coast, including lagoons, important bird areas, and the Słowiński National Park (a UNESCO Biosphere Reserve) with its wandering dunes, are vulnerable.

3. Observations and projections of changes in the flood hazard in Poland

Changes in flood risk are driven by changes in the climatic system (heavy precipitation, snow cover, and drivers of snowmelt, river freeze-up and break-up), the hydrological/terrestrial system (land-use change, urbanisation, river regulation – channel straightening, change of channel width, construction of embankments), and the socio-economic systems (increasing exposure – economic development of flood plains, which generates growth of wealth and damage potential in flood-prone areas).

The water holding capacity of the atmosphere is governed by the Clausius-Clapeyron equation, which states that the saturation vapour pressure grows with temperature (at the rate of 6–7% per 1°C increase in temperature). In other words, warmer air can contain more water vapour. A statistically significant increase in the frequency of intense precipitation has already been observed at many (but not all) meteorological stations, both in Europe (Zolina 2012) and in Poland. Moreover, the structure of the precipitation process has changed: short, isolated precipitation events are now giving way to longer precipitation events (Zolina 2012).

The mean annual and seasonal precipitation has been observed to increase at most weather stations in Poland and to decrease at some others, but many of these changes are not statistically significant. There has been a pronounced, but not ubiquitous, increasing tendency in the intensity of rainfall. However, the inter-annual variability of precipitation is very strong. Changes in the seasonality of precipitation involve a decrease in the ratio of warm-season precipitation to cold-season precipitation (Pińskwar 2009) and also in the proportion of liquid to solid precipitation in winter. The frequency of synoptic weather patterns that are likely to lead to intense precipitation and floods has been on the rise (Niedźwiedź et al. 2014).

There has been an increasing number of local floods in urban areas (flash floods), including large towns (or parts thereof), caused by intense rainfall, when the capacity of the urban sewage systems is too small, or when the urban outflow is obstructed by a flood wave in the river.

Flood damage potential in Poland has increased considerably, in the wake of urbanisation and the ubiquitous increase of wealth. Increasing flood exposure results from human encroachment onto floodplains and the economic development of flood-prone areas. The assets at risk from flooding are high, and growing dynamically. Sensitivity to floods has increased since the change of the political and economic system in the early 1990s, accompanying the constantly (for over 20 years now, including the difficult year 2009) growing national GDP.

Trends established for Polish tide gauge stations show that the annual mean sea level has been increasing over the last century. Observations of sea level changes in Świnoujście belong to the longest series of records, globally (Pruszak & Zawadzka 2008). More recently the sea level rise has accelerated, up to 0.3 cm yr^{-1}.

Historically, the southern coast of the Baltic Sea has always been exposed to flooding and erosion. Over the last 700 years, 82 surges have exceeded 1.2 m AMSL and the 10-year design level is assumed to be 1.5 ± 0.15 m (Pruszak & Zawadzka 2008). A spectacular example illustrating the consequences of coastal retreat is the ruin of the church at Trzęsacz, built in 1250 in the middle of a then village, 700 m from the seashore. In the meantime, the sea has taken away all of that land and almost all of the cliff on which the remains of the church (a single wall – now protected) stand. Since the 1970s coastal erosion, flooding and the frequency and severity of storm conditions has intensified along all of the Polish coast as a result of sea-level-rise, increased storminess and sediment starvation. In recent years, the atmospheric circulation over the Baltic Sea has changed, leading to an increase in the intensity and frequency of north-westerly storms.

Wiśniewski & Wolski (2011) report that the sea level rise rate during a storm surge can be extremely rapid. In January 1993 increases of 72 and 70 cm h^{-1} were reported at Świnoujście and Kołobrzeg respectively.

Projections for the future illustrate the possible greater hazard of rain-generated floods in much of the country, owing to the increasing frequency and amplitude of intense precipitation and increasing frequency of 'wet' circulation patterns. On the other hand, the hazard due to snowmelt flooding is expected to decrease (Kundzewicz et al. 2010).

Future projections based on climate-models show a greater frequency of intense precipitation. The daily precipitation total with an annual exceedance probability of 0.05 (the so-called 20-year 24 h precipitation, that is exceeded, on average, once in 20 years) in the control period 1981–2000 is projected to become more frequent in the whole of central Europe. On average, it will recur every 12–14 years in 2046–2065 and every 9–13 years in 2081–2100, depending on the emission scenario (Seneviratne et al. 2012). These ranges correspond to the mean values for ensembles of climate models.

Projections have to be treated with caution, however. Precipitation, the principal input signal to freshwater systems, is not simulated with adequate reliability in present-day climate models. Projected precipitation changes are model- and scenario-specific, and encumbered with very considerable uncertainty; hence, quantitative projections of changes in river flows at the river basin scale remain largely uncertain. These uncertainties therefore have to be taken into account in the planning process (e.g. of flood protection infrastructure of long lifetime) and in assessments of future vulnerability.

There are many sources of uncertainty in future projections, starting from the impossibility of predicting future human behaviour: population change, social and economic development, climate mitigation policy, controlling future greenhouse gas emissions and carbon sequestration, and hence the intensity of the greenhouse effect. Uncertainties are also introduced by propagation within the system: from greenhouse gas emissions and carbon sequestration to the atmospheric concentration of greenhouse gases, and further to climate change (including feedbacks) and its impacts. Since every component in the system contributes a large amount of uncertainty, this is amplified all along the logical chain from emissions to regional and local impacts. The climate model uncertainty (converting greenhouse gas concentrations into climatic variables, such as temperature and precipitation) is already large. There is a substantial difference between the results obtained using different scenarios and different models. Uncertainties of climate change projections increase with the length of the future time horizon. In the short-term (e.g. the 2020s), climate model uncertainties are dominant. The intra-model uncertainty (for the same model and different socio-economic and emission scenarios) can be lower than the inter-model uncertainty (for the same scenario and different models), especially for not-too-remote future horizons. Over longer time horizons, uncertainties due to the emission scenarios become increasingly significant, however.

Uncertainty in practical water-related projections is also due to the spatial and temporal scale mismatch between coarse-resolution climate models and the smaller-grid scale, relevant to adaptation, for which information on a much finer scale is required. Further, the time scale of interest, e.g. for heavy precipitation resulting in flash flooding as the dynamics of flood routing is on a time scale of minutes to hours, differs from the results of available climate model (typically given at daily/monthly intervals). This scale mismatch makes disaggregation necessary, and this is another source of uncertainty. A further portion of the uncertainty is due to hydrological models and deficiencies in observation records available for model validation.

Studies based on GCM models envisage a relative sea level rise of 45–65 cm by 2100 as well as an increase in the frequency and strength of storm conditions for Poland's coasts (Pruszak & Zawadzka 2008). Two scenarios used in several studies for the time horizon of 2100 are: a sea-level rise of 30 cm and of 100 cm, which could be respectively called optimistic and pessimistic (Zeidler 1997, Pruszak & Zawadzka 2008). An analysis of the threats of land loss and flood risk was carried out for these two scenarios, and the economic and social costs and losses were assessed. For a 100 cm sea-level rise, more than 2300 km^2 and 230 000 people are vulnerable on Polish coasts and the damage due to loss of land could be nearly 30 billion USD plus 18 billion USD at risk of flooding (1995 prices) (Zeidler 1997). A sea-level rise of 1 m plus possible flooding from storm surges (1.5 m) places the maximum inland boundary at 2.5 m AMSL. Zeidler (1997) determined three impact zones between contour lines 0–0.3 m, 0.3–1 m and 1–2.5 m, respectively covering 845, 883 and 476 km^2, i.e. 2204 km^2 in total. About 30 km^2 of beaches and dunes are likely to disappear. The greatest impacts of accelerated sea-level rise would occur in the far eastern and western regions of the Polish coast, in the deltas of the Vistula and the Odra, with lesser impacts along the central region. Threatened areas include the conurbation of Gdańsk, Sopot and Gdynia, the Żuławy (Vistula Delta) polders, and the low-lying areas around the Szczecin Lagoon and the Odra river mouth. These threatened areas are densely populated and of key importance to the Polish economy. The agricultural area of the vulnerable Żuławy polders is about 1800 km^2, that is, nearly 0.6% of the total area of Poland. The Hel Peninsula, narrow and low, is already vulnerable in places. This area, of large aesthetic and emotional value to the Polish nation, will be increasingly threatened in the decades to come.

4. Flood defences and flood preparedness systems in Poland

Flood protection and flood management strategies can modify either flood waters, or susceptibility to flood damage and the impact of flooding. One can try to 'keep people away from water' or 'keep water away from people'. There are several adaptation strategies for coping with floods (see Kundzewicz & Schnellhuber 2004). They can be labelled as follows: protection (as far as is technically possible and financially feasible, bearing in mind that absolute protection does not exist), accommodation (living with floods, learning from them), or retreat (relocation of people from flood-risky to flood-safe areas). This last option, e.g. if the state/province purchases land and property in flood-prone areas, aims to rectify maladaptation and floodplain development.

The components of a flood protection and preparedness system can be divided into five categories, as illustrated in Table 1. These categories are recognised as strategies in the STAR-FLOOD Project (see the footnote on the first page of this paper).

One can try to reduce flood risk by structural and technological means (e.g. hard engineering solutions and implementation of improved design standards), or by legislative, regulatory and institutional means (integrated management; revision of guidance notes for planners and design standards). One can avoid or reduce risk by relocation or some other avoidance strategy, by improvements in forecasting systems, and by contingency and disaster plans. One can share loss (insurance-type strategies) but one has to be prepared to take a residual risk. Research (reducing uncertainties) and education on flood risk are essential.

Flood defences in Poland are mostly structural and include embankments and storage reservoirs. Those in the Vistula River basin include embankments with a total length of ca 4700 km, protecting an area of ca 5300 km^2. There are several storage reservoirs playing an important role in the flood protection system along the upland tributaries of the Vistula: Porąbka and Tresna on the River Soła, Czorsztyn and Rożnów on the Dunajec, Solina (460 million m^3) and Myczkowce on the San, Sulejów on the Pilica, and Dębe on the Narew. There are also reservoirs on the Vistula itself, such as Goczałkowice on the Mała Wisła (Small Vistula) and Włocławek on the lower Vistula. The disastrous 1934 flood prompted intensive work on the flood control system on the Vistula's mountain tributaries. To reduce flood risk, flood protection reservoirs at Porąbka on the Soła (completed in 1936) and at Rożnów on the Dunajec (1941) were constructed; half a century later, another reservoir was built at Czorsztyn on the Dunajec.

Table 1. Components of the flood protection and preparedness system envisaged or implemented in Poland, with some examples

Components of the flood protection and preparedness system		
Flood Risk Prevention ('keeping people away from water')		
Spatial planning – identification of flood risk areas	Enforcement of zoning – restriction of settlement in risk areas	Relocation of inhabitants of flood risk areas
Structural Flood Defence ('keeping water away from people' via infrastructural works)		
Dykes, floodwalls and embankments	Dams and storage reservoirs	Relief channels
Flood Mitigation (reducing the adverse consequences of flooding)		
Watershed management ('keeping the water where it falls')	Storing water in the landscape (surface storage, polders, soil storage, groundwater storage). Restoration of wetlands and floodplains	Building codes. Standards for building development
Flood Preparation		
Preparation of a flood management plan for an imminent flood	Preparation of a flood forecasting and flood warning system	Evacuation plan
Flood Recovery		
Insurance and emergency financing schemes		Legislation enhancing recovery

The flood protection system in the Odra river basin consists of embankments, weirs, reservoirs (including dry flood protection reservoirs, i.e. polders), and relief channels. In the nineteenth century, the length of the River Odra from Racibórz to Schwedt was made 26.4% shorter by digging channels. Regulation has continued since then. There are 23 weirs on the Odra itself (19 built before the end of World War Two), serving principally navigation and hydropower. There are also several reservoirs on the Czech tributaries of the Odra.

However, the total capacity of water storage reservoirs in Poland is only 6% of the mean annual runoff. Several reservoirs are sited in the southern, highland, part of Poland, but in the lowlands, and Poland is a predominantly flatland country, construction of a dam necessitates the inundation of a larger area.

There is a recognised need to strengthen flood protection systems for larger towns like Sandomierz on the Vistula and Opole and Wrocław on the Odra. Past floods such as those in 1997 and 2010 have exposed the inadequacy of existing structural defences.

Structural measures physically modify the environment, whereas non-structural measures change people's behaviour. Indeed, we must change our behaviour (software), and not just build defences (hardware).

The Polish people are increasingly acknowledging the importance of non-structural flood protection. One of the options being considered is watershed management ('to keep the water where it falls' and to reduce surface runoff and erosion) and the restoration of wetlands and flood-plain forests, re-connection of old river arms, and identification of areas-to-be-inundated in an emergency. There is a call to 'give more space to the rivers'. Further, legal regulations are being implemented/envisaged related to the use of flood-plain areas, such as restrictions on new infrastructure and on handling substances dangerous to water in households. It is important to improve social awareness of the flood risk.

Early warning (Kundzewicz 2012) is an important part of any flood preparedness system, reducing the destructive impact of floods on vulnerable areas in terms of lives and material damage. A flood warning is timely information based on a reliable forecast that a high water level (or high river discharge) is expected to occur in a river cross-section of interest at some defined future point in time, so that emergency action, such as strengthening dykes or evacuation, can be undertaken. A flood alert, usually issued before a flood warming, is less specific and aims at raising vigilance. A warning should be issued sufficiently early (this depends on catchment size relative to vulnerable zones in terms of possible lead times) before the potential inundation, in order to allow adequate human preparations. It should persuade people to take appropriate action in order to reduce the damage and costs of the forthcoming flood. A flood forecasting and warning system has been operating in Poland. After the 1997 flood it was considerably strengthened and now includes radar.

Water management decisions have always been made on the basis of uncertain information. Yet changes in climatic, terrestrial and socio-economic systems challenge existing water management practices by adding uncertainties and novel risks that are often beyond the range of experience. Adaptation, both reactive and anticipative, makes use of a feedback mechanism, implementing modifications (and possibly correcting past mistakes) in response to new knowledge and information (from monitoring and research – modelling studies producing scenarios).

Water resources systems have been traditionally designed and operated on the basis of the stationarity assumption: the past is the key to the future (Kundzewicz et al. 2008). However, 'stationarity is dead' (Milly et al. 2008), hence existing standard design procedures cannot be optimal for changing conditions: systems can be under- or over-designed, resulting in either inadequate performance or excessive costs (e.g. with a large safety margin).

Every dyke is designed to withstand an N-year flood, e.g. a 100-year flood, so it can be overtopped and/or breached/washed away, if a much higher flood occurs. But the notion of a 100-year flood has to be revisited in the light of ongoing, and projected, changes. The 100-year flood for a past control period is unlikely to be of the same amplitude as a 100-year flood in a future time horizon, which is of importance for large water infrastructure (e.g. dykes, dams and spillways). However, because of the difficulty in isolating the greenhouse signal in the observation records and the large uncertainty of projections for the future, no precise, quantitative information can be delivered. In some countries (like Germany, the UK and the Netherlands), flood design values have been increased by a safety margin based on existing climate change impact scenarios. A 'climate change factor' has been tacitly introduced, which is to be taken into account in any new plans for flood control measures.

Planning horizons and lifetimes for some adaptation options (e.g. dams) may be many decades, during which time information is expected to change. Existing climate projections for the future are encumbered with a high degree of uncertainty. Despite recent progress in evaluating uncertainties (e.g. via ensembles-based studies), quantitative projections of changes in river runoff remain largely uncertain (Kundzewicz et al. 2007, 2008, 2009). Hence the question may arise – adapting to what?

There is the opportunity cost of failure to act early vs. the value of delay (narrower range of uncertainty) and the controversy about whether to adapt now to existing (strongly uncertain) projections or to wait for more accurate and trustworthy information and then adapt (possibly having missed the opportunity for advanced adaptation).

Uncertainty in climate impact projections has implications for adaptation practices. Adaptation procedures need to be developed that do not rely on precise projections of changes in river discharge. Water managers can no longer have confidence in an individual scenario or projection for the future, because it is difficult to evaluate its reliability. Hence, multi-model probabilistic approaches are preferable to using the output of only one climate model when assessing uncertainty in climate change impacts. The broad range of different model-based climate scenarios suggests that adaptive planning should not be restricted to just one or a few scenarios, since there is no guarantee that the range of simulations adequately represents the full possible range (Kundzewicz et al. 2007).

Since the uncertainty in projections for the future is large, a precautionary attitude is advisable when planning adaptation. There is no doubt that better accommodation of the extremes of present climate variability augurs better for the future climate, which is subject to change.

Most severe floods, in terms of fatalities and material damage, have occurred in large river valleys, especially in conurbations and industrial areas protected by embankments. The design of dykes is based on probabilistic measures, but these do not give a complete guarantee. Dykes may offer a reasonable level of protection against a small-to-medium flood; but when an extraordinary flood occurs and dykes fail to hold back the water masses and break or are overtopped, the damage is greater than it would have been if the dyke had not existed. This is so because dykes are commonly (but mistakenly) treated as affording absolute protection and attract development. Several towns were devastated by the floods in 1997 (Kłodzko, Racibórz, Opole, Wrocław) and 2010 (Sandomierz).

In the context of increasing flood hazards and/or flood risks, the upgrading of structural defences (e.g. expanding the enclosures within embankments and improving the existing embankments around low-lying areas, raising and strengthening dykes, enlarging reservoirs etc.) and revision of the management regulations for water structures would be needed. The upgrading of drainage systems (in particular of urban drainage) for a future, wetter, climate is also necessary. Another (very costly) option is the relocation of industry and settlements from flood plains. A small-scale structural action is flood-proofing on site, i.e. adapting existing building codes to ensure that long-term infrastructure will withstand future climate risks.

Coastal defences on the southern coast of the Baltic Sea have been built since the 19th century. Coastal protection structures, consisting mostly of groynes and revetments, exist along ca 26% of the Polish coastline (Pruszak & Zawadzka 2008). Three adaptation options are being considered in the context of climate change adaptation in the Polish coastal zone: retreat, limited protection and full protection. The total cost of all protection measures in the whole coastal zone of Poland, at 1995 prices, is 6 billion USD (Zeidler 1997), i.e. 8 times less than the total cost of land loss due to sea-level rise, including storm surge effects. The protection measures include strengthening existing defences and constructing new defences. In the Vistula Delta, full protection is required, consisting of storm and flood prevention facilities. It is estimated that 107 and 280 km respectively of new dykes will have to be constructed for sea level rises by the year 2100 of 30 cm and 1 m; the respective lengths of dykes requiring improvement are 243 and 324 km for the same scenarios (Pruszak 2000). However, since the uncertainty in climate change projections is high, monitoring the situation and updating plans are necessary on an almost continuous basis.

5. European Union Floods Directive

In response to a number of recent destructive inundations in Europe since the 1990s, such as the summer floods in 1997 and 2002, the EU Floods Directive (CEC 2007) was adopted. The Directive obliges EU Member States to undertake, for each river basin district or the portion of an international river basin district or coastal area lying within their territory:

- a preliminary flood risk assessment (a map of the river basin; description of past floods; description of flooding processes and their sensitivity to change; description of development plans; assessment of the likelihood of future floods based on hydrological data, types of floods and the projected impact of climate change and land-use trends; forecast of estimated consequences of future floods);
- preparation of flood maps and indicative flood damage maps, for areas which could be flooded with a high probability, with a medium probability and with a low probability (extreme events);
- preparation and implementation of flood risk management plans, aimed at achieving the required levels of protection.

After having entered the European Union on 1 May 2004, Poland contributed to the collaborative, pan-European work on the preparation of the EU Floods Directive (No. 2007/60/WE). It was published in the Polish legislative periodical *Dziennik Ustaw* (Dz.U. UE L 288/27). The implementation of the Directive in the Polish legal system was regulated by the updated 'Water Law' of 5 January 2011 (Dz.U. Nr 32, poz. 159) that came into force on 18 March 2011.

Since the Floods Directive is closely related to the implementation of the Water Framework Directive, road maps for the implementation of both these directives have to be fully synchronised. It is desirable, therefore, that social consultation processes should be closely coordinated. Coordination of the implementation of these directives should help complementary objectives to be achieved.

Article 17 of the Floods Directive states that 'Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive before 26 November 2009'. This deadline was not met by Poland. This objective was achieved later, on 5 January 2011, by passing the regulation changing the 'Water Law' and some other regulations (Dz.U. 2011 No. 32 item. 159) [in Polish: *ustawa z dnia 5 stycznia 2011 r. o zmianie ustawy – Prawo wodne oraz niektórych innych ustaw* (Dz.U. 2011 Nr 32 poz. 159)].

Important deadlines were envisaged in the implementation of the Floods Directive in 2011 and 2013. Chapter II, item 4 of the Floods Directive required that Member States should complete the preliminary flood risk assessment by 22 December 2011. The Chairperson of the National Board of Water Management approved the preliminary flood risk assessment on 21 December 2011, thereby meeting the deadline required by the Floods Directive. The document was prepared by the Institute of Meteorology and Water Management (State Research Institute) through its Centres of Flood Modelling in Gdynia, Poznań, Kraków and Wrocław, in consultation with the National Water Management Board. The draft document was sent to provincial governors and marshals for their comments, and after consideration of these, to the Director of the Government Centre for Security. The preliminary flood risk assessment was carried out within the framework of the Information System of National Protection against Extraordinary Hazards (Polish abbreviation – ISOK), financed from the European Regional Development Fund – Operational Programme: Innovative Economy.

Chapter III, item 8 of the Floods Directive required that Member States should ensure that the flood hazard maps and flood risk maps are completed by 22 December 2013. The methodology for compiling such maps in Poland was specified by a Decree of the Minister of the Environment, the Minister for Infrastructure and Minister of the Interior and Administration. The methodology defines the content range of maps, the quality of source data and the timetable for their implementation and publication. Such maps, based on current geodetic and cartographic data, including the precise digital terrain model developed from airborne laser scanning data, were prepared within the ISOK project (Kurczyński 2012) by a consortium led by the Institute of Meteorology and Water Management, embracing the National Board of Water Management, the Main Office of Geodesy and Cartography and the National Institute of Telecommunications, as well as the Government Centre for Security as a supporting body.

The directors of regional water management boards are responsible for the production of flood hazard maps and flood risk maps in a water region. Following the decision of the Chairperson of the National Water Management Board, these maps were to be compiled by the Flood Modelling Centres affiliated to the Institute of Meteorology and Water Management.

The maps have been forwarded to nine groups of addressees (Chairperson of the Water Management National Board, Principal National Geodesist, Main Inspector of Environmental Protection, Director of the Government Centre for Security, the relevant provincial governors and marshals, rural and urban district authorities, and the relevant commanders of provincial, district or urban fire brigades).

The extent of flood-endangered areas shown on the maps will be taken into consideration in the spatial management practices of the country and the provinces, studies of conditions and spatial management in communes, and local spatial management plans.

Within 18 months of receiving the maps, the public administration bodies listed above will take account of these areas in spatial management plans and studies, and the costs of introducing these changes will be covered by the budgets of the relevant communes or provinces.

The principle of subsidiarity guiding EU policy means that Member States have to react flexibly to the specific challenges in their countries. Adaptation is basically local. However, the EU acts as coordinator where trans-boundary issues and sectoral policies are concerned. It provides co-funding for a range of projects (including infrastructure). The EU supports research, information exchange, awareness-raising and education. In other words, it creates a favourable environment for such adaptation.

It is expected that implementation of the Floods Directive, the most advanced legislation worldwide in the area of flood protection and flood preparedness, will help reduce the flood risk in Poland.

6. The public debate on flood risk and flood preparedness

The Polish nation has suffered considerably from floods, so that a vigorous public debate on flood risk and flood preparedness has taken place. This was particularly apparent during and following the disastrous flood in July 1997 (Kundzewicz et al. 1999). Public opinion polls showed the nation to be critical towards the central government, and this criticism may have contributed to the defeat of the then ruling coalition in the subsequent parliamentary elections, as noted by many an international observer. Some provincial authorities who underestimated the danger and did not make proper use of the forecasts were strongly criticised. The 1997 flood demonstrated the considerable capabilities of local authorities, whose performance was evaluated more favourably. In several locations they managed to combat the hazard. This statement became important in a nationwide discussion about the territorial structure of Poland on whether or not to replace the existing administrative division into 49 provinces (Polish – *województwa*) by a smaller number of larger units and whether or not to introduce an intermediate level of districts (Polish – *powiaty*) between the provinces and municipalities (Polish – *gminy*). The flood provided ample demonstration of the inefficiency of the existing flood protection structure and of the division of responsibilities.

The 1997 flood made arrogant politicians and militant environmentalists alike eat humble pie. The new reservoir at Czorsztyn on the Dunajec, the subject of a violent dispute that had gone on for decades, proved to play a useful and spectacular role during the flood, saving many settlements from inundation.

The 1997 event was extensively covered by the Polish media. For several weeks, it was the dominant topic in the press and the principal theme of the cover stories of weekly magazines, including four issues of the opinion-forming *POLITYKA* (see Figure 1).

Figure 1. A sample of the covers of Polish weekly magazines in the summer of 1997 relating to the flood topic

The 1997 flood theme in Poland was intimately interwoven into the election campaign by the media. Indeed, politicking around the flood became quite common. As a result, many members of the public got the feeling that flood losses could have been prevented and that it was only the inefficiency of the authorities that had led to disaster. Yet in the light of objective hydrological data, it is absolutely clear that the disaster could not have been avoided.

Destruction, panic and chaos in the flood-affected areas of Poland (the Upper Odra and its tributaries) during the first wave of the flood in July 1997 was set against the '*Ordnung*' of the preparatory action on the German side of the border along the Lower Odra. Yet this was at the time when the flood peak was still a long way upstream of the Lower Odra. When high water did eventually arrive in the Słubice/Frankfurt area, it turned out that the dykes on the Polish side, which had earlier been massively reinforced, withstood the pressure of the water, whereas those on the German side broke in several places, resulting in large-scale inundations and catastrophic material damage.

After decades of censorship in the totalitarian communist system, the freedom of press has become an essential human right in the new, democratic, Poland. Yet, during the flood, the absolute freedom of the press did not always rhyme with responsibility. Chasing sensations did not serve the flood defences well. Very often high-profile individuals – laymen where floods and hydrology are concerned – played the expert and shared their (mostly critical) opinions on the flood action through the media. Questioning individual decisions pertinent to flood management (e.g. moving amphibious vehicles from central Poland into the flooded zone) was not uncommon. Furthermore, the media presented 'alternative' forecasts, some of which largely underestimated the amount of precipitation during the second flood wave that IMGW forecast with good accuracy.

Mr Krzysztof Szamałek, Deputy Environment Minister and Deputy Head of the ad hoc high level emergency committee for the coordination of flood mitigation (Anti-Crisis Committee), stated that 'such a flood could neither have been foreseen, nor remedied' and rightly heralded it as 'the largest natural disaster in the 1000-year history of Poland'. Indeed, if an existing all time flood record is doubled, as in the case of the flow rate of the River Odra at the Racibórz-Miedonia gauge, and the flood recurrence interval lies within the range of thousands of years, there is no way of avoiding material losses. The flood's magnitude was unprecedented, far beyond existing experience. For decades, people had got used to floods along the Odra and its tributaries. They knew where the safe places were in an emergency, where to find shelter for animals and cars. This time, however, the water entered the usual safe havens.

The dramatic Odra flood in July 1997, occurring after a long flood-free period, made the general public aware of how dangerous and destructive a flood can be. It also demonstrated the weaker and stronger points of the existing flood protection system and helped to identify the aspects that needed urgent improvement. Indeed, every link in the chain of operational flood management (observation – forecast – response – relief) was found wanting. However, the nation has learnt the lesson and has ever since been working on improving the flood preparedness system.

The catastrophic flood in July 1997 demonstrated that the flood protection systems for larger towns and cities like Wrocław, Legnica, Opole, Racibórz and Lwówek Śląski were inadequate. In addition, vast areas of agricultural land along the stretch of the Upper Odra to Krzepkowice and in the valleys of the Upper Odra's tributaries were not adequately protected.

The system of anti-flood committees turned out to be inefficient: before 1997, they had never been involved in action on this scale. Even the maps these committees possessed were outdated. Moreover, the units involved in the action, such as the Anti-flood Committee and the Army, had outdated instructions and directives (e.g. delegating long non-existent military units to combat the flood). There was no clearly defined 'division of labour' for the participation of the Army, Police and Fire Brigades in flood actions; neither were the financial consequences of such actions taken into account. The dissemination of information on floods in the provinces, towns and villages was practically non-existent. No suitable civil defence force was available in the country; the existing one was geared to act in case of war rather than in an emergency during peacetime, such as a natural disaster.

During the 1997 flood, the relevant legislation in Poland, being a country in transition, was found deficient. Therefore the previous (communist) regime's laws were essentially abandoned and new Acts of Parliament had to be passed during a short time. The distribution of responsibilities was ambiguous and conflicting, and there were complicated links between the different participants in flood defence activities. According to the legislation existing at the time, local authorities were not authorised to declare a flood alert or alarm. Such declarations had to be made by the provincial anti-flood committees and, as a result, they were issued with much delay, often after the crest of a flash flood in one of the Odra's mountain tributaries had passed. Hence, local authorities typically took common-sense decisions, without waiting for instructions from above. In addition, the information flow was deficient; hydrometeorological stations reported to the regional branches of the hydrometeorological service (albeit making information available, on request, to local authorities as well). Some of the forecasts proved to be inaccurate.

Among the downsides of the forecasting and warning system was the telecommunication support. Classical telecommunication links were disconnected. Even if mobile phones provided more reliable communication, the system turned out to have limitations.

Advance warning on the Odra was available for its medium and lower course when the flood developed in its headwaters in the Czech Republic and Poland. The State of Brandenburg in Germany had ten days before the arrival of the floodwater. Yet detailed forecasts were difficult to obtain, for example, because observations at several gauges were interrupted and the flood information office in Wrocław was itself flooded.

It was recognised that the following work needed to be carried out: modernisation of the weather radar network and stream/rain gauges; automation of data transmission; technical upgrading of flood warning centres, including telecommunication facilities (phone, radio, fax, if necessary, capable of operating without a mains supply); upgrading of the early warning system by enhancing the regional, interregional and international flow of flood-related information; constructing more suitable forecast models.

Since the 1997 flood, there has been considerable investment in Poland aimed at improving the flood preparedness systems; this includes strengthening the flood forecasting and warning systems (e.g. the broader use of modern technology, radar, models, GIS). Efforts have been made to upgrade the monitoring systems, and to render stream gauges, communication and data transmission systems more robust and more reliable than during the 1997 flood.

In the last ten years or so, large-scale flood protection programmes have been developed in Poland, such as the 'Programme for the Odra 2006' and the 'Programme of flood protection in the Upper Vistula basin'. However, these programmes have given rise to mixed opinions nationally and internationally, including criticism from the European Commission and NGOs. The strategy was based on assumptions rather than on serious considerations of efficiency. The structural approach of constructing dykes and dams, proposed in the programmes, has been rated by many as insufficient.

The programmes assumed that the flood risk would be reduced by the implementation of the (very costly) measures specified in the programmes. A sarcastic saying was coined (Janusz Żelaziński, personal communication), referring to the costs and effects of flood protection measures in complex-numbers parlance, namely, that the costs are real, but the effects are imaginary.

The debate on flood preparedness and the progress made in implementing the EU Floods Directive in Poland is ongoing.

In the light of the destructive floods in Poland in May and June of 2010, there was broader concern in the nation as to whether the implementation of the EU Floods Directive was on schedule. This concern was encapsulated in a formal parliamentary interpellation by Mr Michał Jaros, MP, who posed the following questions: 'How advanced is the work on the first stage of implementing the Directive, i.e. the adaptation of Polish law? What are the reasons for the delay in implementing the Directive?'. In response, Mr Bernard Błaszczyk, Deputy Minister for the Environment, outlined the chronology of activities that were essential for implementing the Floods Directive in Poland. In his opinion, the process was highly complex, owing to its interdisciplinary nature. Moreover, the need to change existing regulations required inter-sectoral negotiations, and that would take time.

Indeed, Poland is striving to meet the obligations resulting from particular steps requested by the EU Floods Directive.

7. Concluding remarks

Flooding – the most destructive natural hazard in Poland – includes floods from rivers and mountain torrents, as well as floods from sea surges in coastal areas, and overflow in sewer systems. There have been several large floods in Poland in the last century and in recent decades, with damage exceeding 1% of the Polish GDP. Flood risk and flood preparedness became matters of widespread concern following the dramatic inundations in Poland in 1997 and 2010. Rainfall floods can occur on all the rivers in the country. The highest flood risk exists in the headwaters of two large rivers – the Vistula (whose drainage basin covers 54% of the country's area) and the Odra (34%). There are many towns and large cities on the Vistula, the Odra and their tributaries. As discussed in this paper, changes in flood risk are driven by changes in the climatic system, in the hydrological/terrestrial system, and in the socio-economic system. The changing flood risk is due to changes in the flood hazard (climate) but also to changes in the parameters of hydrological systems (storage capacity of the landscape, permeability, roughness coefficient, river bed). The increasing intensity and frequency of heavy precipitation and sea level rise, as well as decreasing snow cover and snow melt are the climate change factors contributing to the flood risk.

In order to be prepared for the increasing flood risk, flood protection and flood management strategies are necessary that can modify either the flood waters themselves, or the susceptibility to flood damage and the impact of flooding. In other words, one can try to keep water away from people or to keep people away from water.

The principal issues related to strengthening the flood protection and flood preparedness systems include floodplain management (including the enforcement of zoning) and watershed management. It is necessary to fill information gaps, for example, quantitative precipitation forecasts and climate-relevant long-term projections, as well as to increase the awareness of the endangered population. Moreover, the policies of insurance companies have an important role to play in raising awareness. In urban areas, structural defences are absolutely necessary, as are regular assessments of their technical condition.

Implementation of the Floods Directive of the European Union (EU) is a useful vehicle for assessing, improving and managing the flood risk in Poland. But this is a very demanding exercise in this country, owing to the necessity to harmonise EU law with Polish national law.

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