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ASSESSMENT OF FINANCIAL LOSSES ON FLOOD-PRONE AREAS IN THE ŁÓDŹ PROVINCE

The aim of the research is to assess the current state of land use of flood-prone areas considering potential financial losses as exemplified by 21 communes of the Łódź province which obtained high or very high flood risk levels in the methodology used in *Flood Protection Operating Plan for the Łódź Province*[2]. The flood-prone area was defined as an area particularly exposed to the risk of flooding on which the probability of flooding is on the medium level and amounts to 1%[3]. Financial losses were assessed in accordance with the guidelines included in *the Ordinance of the Minister of the Environment, Minister of Transport and the Marine Economy, Minister of Administration and Digitalization and the Minister of Internal Affairs of 21 December 2012 on elaboration of flood hazard maps and flood risk maps*[4]. Potential financial losses were calculated on the basis of an analysis of land use of flood-prone areas with the use of the Database of Topographic Objects as well as land inventory. Both land use and assessment of losses were presented with the use of GIS methods. It was established that the biggest financial losses within prarticularly flood-prone areas may be found in Tomaszów Mazowiecki as well as in the communes of Gidle and Poddębice, which is connected with the existence of service and production areas as well as residential areas. Analysis of flood risk levels is of great importance as it may allow to implement an adequate flood protection policy[5].
Keywords: areas at risk of flooding, property damage, hazard maps and flood risk, GIS.

1. INTRODUCTION

Worldwide floods are a cause of huge losses, especially if they occur on densely populated and intensively developed areas. Appreciable financial resources are allocated to flood preparedness. Decisions concerning the use of flood protection means are made

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[3]*Ustawa z dnia 18 lipca 2001 r. Prawo wodne.[Water Law Act as of July 18, 2001]*.

[4]*Rozporządzenie Ministra Środowiska, Ministra Transportu, Budownictwa i Gospodarki Morskiej, Ministra Administracjii Cyfryzacji oraz Ministra Spraw Wewnętrznych z dnia 21 grudnia 2012 r. w sprawieopracowywania map zagrożenia powodziowego oraz map ryzyka powodziowego*, (Dz.U. 2013, poz. 104) [*Ordinance of the Minister of the Environment, Minister of Transport and the Marine Economy, Minister of Administration and Digitalization and the Minister of Internal Affairs of 21 December 2012 on elaboration of flood hazard maps and flood risk maps*.

[5] M.Borowska-Stefańska,*Zagospodarowanie terenów zagrożonych powodziami w województwie łódzkim*, Wydawnictwo Uniwersytetu Łódzkiego, 2015c, p. 126.

as a result of assessing costs and benefits resulting from these activities. From the point of view of the economy the money spent on flood prevention should not exceed the expected outcomes. This is why it is so important to assess losses adequately in the process of flood risk management[6].

Flood risk is defined as a product of risk (physical and statistical flood characteristics), exposure (who and what is threatened by flooding) and sensitivity (susceptibility of land use elements to floods and ability to counteract and eliminate consequences of flooding)[7].

Flood losses tend to be divided into direct and indirect ones or financial and non-financial. Direct losses result from the direct impact of flooding on people, property and the environment. They include, for instance, loss of health or life of people, damaging residential development, technical infrastructure, contamination of ecosystems, damage in the agriculture. Indirect losses are caused by long-term consequences of flooding and include, among other things, losses connected with reduced production resulting from damaged electric power, transport and telecommunications infrastructure or loss of profits on the part of companies. This type of losses tends to concern an area which is larger than the actual rea where flooding occurred. In addition to that, the time when flooding has an impact on flooded areas is longer than the time of flooding itself [8]. Financial losses include, in turn, those losses which may be easily discussed in money categories, including losses of property or production[9]. Human health and life or environmental values are not objects of trade on the market, which is why it is much more difficult to assess them in terms of money[10].

The most important elements of economic assessment of flood damage include: flood intensity, quantity, type and location of facilities exposed to flooding, value of property and its sensitivity to flood hazards. Flood losses depend on a range of factors, such as: flow speed, flood duration, contamination, water levels and many others[11]. These aspects, however, are rarely taken into account in flood loss models, and there is a tendency to take only the depth of flooding into consideration[12]. Data concerning the number, type and location of property tend to be given through information on land use obtained from field research or existing sources. Information on the value of losses expressed in money may

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[6] J.-L. Kang, M.-D. Su, L.-F. Chang, *Loss functions and framework for regional flood damage estimation in residential area*, "Journal of Marine Science and Technology" 2005, no 13, p. 193.

[7] B. Merz, A.H. Thieken, *Floodriskanalysis: conceptsandchallenges*, „OsterreichischeWasser und Abfallwirtschaft" 2004, vol. 56, no. 3–4, p. 27.

[8] M. Sowiński,*Szkody powodziowe jako element wyznaczania ryzyka*, „Infrastruktura i ekologia terenów wiejskich" 2008, No 7, Polska Akademia Nauk, Oddział w Krakowie, p. 124.

[9] F. Messner, V. Meyer, *Flood damage, vulnerability and risk perception – challenges for flood damage research*, UFZ Discussion Paper 13, 2005, p. 3.

[10] V. Meyer, F. Messner, *Guidelines for direct, tangible flood damage evaluation* [in:] *Evaluating flood damages: guidance and recommendations on principles and methods*. ReportNo. T09-06-01, 2007, (http://www.floodsite.net/ - access: 29.09.2015), p. 9.

[11] I. Kelman, R. Spence, *An overview of flood actions on buildings*, „Engineering.Geology" 2004, vol. 73, no. 3–4, pp.298-299.

[12] A.H. Thieken, M. Müller, H. Kreibich, B. Merz, *Flood damage and influencing factors: New insights from the August 2002 flood in Germany*, „Water Resources Research" 2005, vol. 41 (http://onlinelibrary.wiley.com/doi/10.1029/2005WR004177/epdf. access: – 12.11.2015), p. 1.

be given in two ways: as an aggregate value of real estate and property on the flood-prone area or as the volume of losses by flood characteristics, mainly depth[13].

The main idea behind assessing flood losses is the notion of the damage function or loss function. It defines the sensitivity of flood-prone property to some flood characteristics, such as the depth of flooding[14]. This function reflects the vulnerability of land use elements to flooding. What most loss functions have in common is the fact that direct financial losses are connected with the building type or use and the depth of flooding[15]. Loss functions for buildings tend to be elaborated on the basis of data gathered after floods[16]. The result for most loss functions is absolute money loss for the building, some approaches also ensure relative loss functions and in that case losses are quoted as a percentage loss of the building value [17]. The biggest part of literature concerning assessment of losses refers to direct measurable losses[18]. In this article the aim of the research is to assess the current state of land use of flood-prone areas considering potential financial losses in 21 communes of the Łódź province which obtained high or very high flood risk levels in the methodology used in*Flood Protection Operating Plan for the Łódź Province*[19].

In Poland the problem of development of flood hazard areas and assessment of losses due to flooding is dealt with by the National Water Management Authority (Polish: KZGW), the Institute of Meteorology and Water Management (Polish: IMGW), the Head Office of Land Surveying and Cartography (Polish: GUGiK), the Crisis Management Centre (Polish: RCB) and the National Institute of Telecommunications. There is a project entitled ”IT System of the Country's Protection against extreme hazards,” which resulted in preliminary assessment of flood risk, flood hazard maps and flood risk maps. Flood hazard maps and flood risk maps were published at the end of 2013, yet guidelines providing for them were established already in the Regulation of the Minister of the Environment, the Minister of Transport, Construction and Marine Economy, the Minister of Administration and Digitalization and the Minister of Internal Affairs as of 21 December 2012 on elaboration of flood hazard maps and flood risk maps. These documents had to be elaborated in accordance with the provisions of the Floods Directive[20]. The main aim of this document is to reduce the flood risk and minimize the consequences of floods, adequate management of the risk which may be posed by floods for human health, the environment, economic activity and cultural heritage as well as preparation of citizens to deal with a flood event[21]. This is the only document which

[13] V. Meyer, F. Messner, 2007, *op. cit.*, p. 24.
[14] F. Messner, V. Meyer, *op. cit.*, p. 12.
[15] H. G. Wind, *T.M.* Nierop T. M., C. J.de Blois, J. L de Kok, *Analysis of flood damages from the 1993 and 1995 Meuse flood,* "Water Resources Research" 1999, *vol. 35, no. 11, p. 3460.*
[16] A.H. Thieken, M. Müller, H. Kreibich, B. Merz, 2005, *op. cit.*, p. 2.
[17] D. Dutta, S. Herath, K. Musiake, *A mathematical model for flood loss estimation*, "Journal of Hydrology"2003, vol. 277, no. 1, p. 29.
[18] A. H. Thieken, M. Müller, H. Kreibich, B. Merz, 2005, *op. cit.*, p. 1.
[19]*Plan operacyjny ochrony przed powodzią dla województwa łódzkiego*, 2013, *op. cit.*, p.16.[*Flood Protection Operating Plan for the Łódź Province, 2013]*.
[20]http://www.kzgw.gov.pl/Dyrektywa-Powodziowa.html (acceess: 27.11.2013).
[21]J. Rotnicka, *Gospodarka wodna w świetle uwarunkowań Unii Europejskiej* [in:] *Stan gospodarki wodnej w Polsce - problematyka prawna i kompetencyjna* (na przykładzie Dolnej Wisły), Materiały

clearly refers to flood risk assessment in Poland. It lacked, however, differentiation of flood risks within the flood hazard areas.

Regrettably, it lacks a detailed analysis of land use and volume of financial losses on flood-prone areas in relation to administrative units[22].

2. RESEARCH METHODOLOGY AND SOURCE MATERIALS

In order to assess land use of flood-prone areas the author used the Database of Topographic Objects and carried out land inventory aimed at updating the base[23]. Subsequently, layers of coverage and land use obtained from the Database of Topographic Objects were merged using GIS tools. Overlapping of these two layers gave a detailed picture of land use on areas particularly exposed to the risk of flooding. This made it possible to assign individual functions to a specific group in a newly established classification.

Assessment of financial losses was made in accordance with the guidelines included in *the Ordinance of the Minister of the Environment, Minister of Transport, and the Marine Economy, Minister of Administration and Digitalization and the Minister of Internal Affairs of December 21, 2012 on elaboration of flood hazard maps and flood risk maps*[24]. Under these guidelines the following areas of land use should be specified to define potential property losses on flood-prone areas: housing estates, areas of economic activity, transportation areas, forests, recreation areas, cultivated land, waters and other areas for which flood losses are not defined (wasteland). This classification is partly used in this article with the difference that cultivated land was divided into arable land and grassland as potential financial losses tend to be higher on arable land. Service and production areas as well as technical infrastructure areas were separated from areas of economic activity. Technical infrastructure facilities, especially water purification plants and landfill sites, represent a potential source of contamination and may bring about negative consequences for the natural environment and people in the event of inundating the area by flood water.The value of potential unit losses for residential areas, areas of economic (service and production) activity as well as transportation areas is calculated as a product of property value in in the given use class and loss function specifying the degree of property losses in relation to water depth. Constant values are adopted for the remaining land use classes regardless of water depth as it has a rather insignificant impact on the degree of reduction in property value. The potential value of losses was specified for water depth ranging from 0.5 to 2 m. It is only the combination of these three elements: land use, water depth and property value (which is diversified for residential areas and areas of

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z konferencji zorganizowanej przez Parlamentarny Zespół ds. Dróg Wodnych i Turystyki Wodnej 2 czerwca 2011 r. w siedzibie Senatu, Kancelaria Senatu, 2011, p. 21;

[22]M. Borowska-Stefańska, *Flood risk assessment of Łodź province communes*, "Humanities and social sciences" 2015a, , Vol. XX, 2015, p. 14.

[23]Baza Danych Obiektów Topograficznych, WODGiK [the Database of Topographic Objects].

[24]*Rozporządzenie Ministra Środowiska, Ministra Transportu, Budownictwa i Gospodarki Morskiej, Ministra Administracji i Cyfryzacji oraz Ministra Spraw Wewnętrznych z dnia 21 grudnia 2012 r. w sprawie opracowywania map zagrożenia powodziowego oraz map ryzyka powodziowego*, (Dz.U. 2013, poz. 104) [*Ordinance of the Minister of the Environment, Minister of Transport and the Marine Economy, Minister of Administration and Digitalization and the Minister of InternalAffairs of 21 December 2012 on elaboration of flood hazard maps and floodriskmaps*.

economic activity according to the province) that is used to assess potential losses expressed in money (table 1)[25].

Table 1. The value ofproperty lossin the Łódź regiondue toland useclass

Class of land use	**The value of assets in the range water depths 0,5 < h ≤ 2 m**
Residential areas	101,83 zl/m²
Economicactivity	331,68 zl/m²
Transportationareas	43,6 zł/m²
Forests	80 zl/ha
Recreationalareas	5,1 zl/m²
Arable land	1428 zl/ha
Grassland	674 zl/ha

Source: Rozporządzenie z dnia 21 grudnia 2012r. w sprawie opracowywania map zagrożenia i map ryzyka powodziowego.[*Ordinance of the Minister of the Environment, Minister of Transport and the Marine Economy, Minister of Administration and Digitalization and the Minister of Internal Affairs of 21 December 2012 on elaboration of flood hazard maps and flood risk maps]*.

Data on the potential volume of losses were fed into the GIS and calculations were made with the use of the Model Builder tool (fig. 1)[26].

[25]M. Borowska-Stefańska, *Ocena potencjalnych strat materialnych na terenach zalewowych, wyznaczonych dwoma metodami, w wybranych miastach województwa łódzkiego,* „Problemy Rozwoju Miast, Kwartalnik Naukowy Instytutu Rozwoju Miast" 2015b, Rok XII, Zeszyt IV, p. 10.
M. Borowska-Stefańska,2015c, *op. cit.*, p. 30.
M. Borowska-Stefańska, *Zagospodarowanie terenów zagrożonych powodziami w wybranych miastach województwa łódzkiego*, „Prace Geograficzne" 2015d, z. 140, p. 65.
[26]M. Borowska-Stefańska, 2015b, *op. cit.*, p. 10.

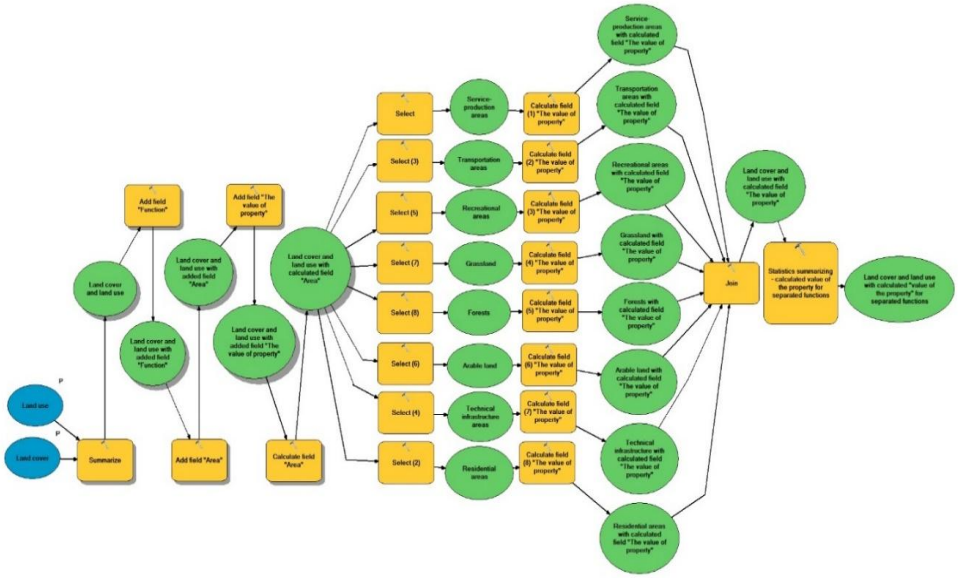

Fig. 1. The use of GIS tools to estimate potential financial losses on flood-prone areas in small towns of the Łódź province
Source: Borowska-Stefańska 2015b.

3. RESEARCH AREA

The Flood Protection Operating Plan for the Łódź Province[27] points to 21 communes from the province in total which are characterized by high or very high flood risk levels. They are located in the catchment areas of three main rivers:

1) The Warta river – Gidle (a rural commune on the rivers of Warta and Mękwa), Radomsko (a rural commune on the rivers of Warta and Radomka), Ładzice (a rural commune on the Warta river), Działoszyn (an urban and rural commune on the Warta river), Burzenin (a rural commune on the Warta river), Zapolice (a rural commune on the rivers of Warta and Widawka), Sieradz (a rural commune on the rivers of Warta, Myja and Żeglina), Sieradz (a town on the rivers of Warta and Myja), Warta (a rural commune on the rivers of on the Warta river), Pęczniew (a rural commune on the Warta river), Poddębice (a rural commune on the rivers of Warta and Ner), Uniejów (an urban and rural commune on the Warta river);

2) The Pilica river – Żytno (a rural commune on the Pilica river), Rozprza (a rural commune on the Luciąża river), Sulejów (an urban and rural commune on the rivers of Luciąża and Pilica), Czarnocin (a rural commune on the Wolbórka river), Tomaszów Mazowiecki (a rural commune on the rivers of Pilica, Wolbórka, Czarna and Piasecznica), Tomaszów Mazowiecki (a town of the rivers of Pilica, Wolbórka, Czarna and Piasecznica), Inowłódz (a rural commune on the Pilica river);

[27] *Plan operacyjny ochrony przed powodzią dla województwa łódzkiego*,2013, *op. cit.*[*Flood Protection Operating Plan for the Łódź Province, 2013].*

3) The Bzura river – Kutno (a town of the Ochnia river), Łowicz (a town of the Bzura river) (fig. 2)[28].

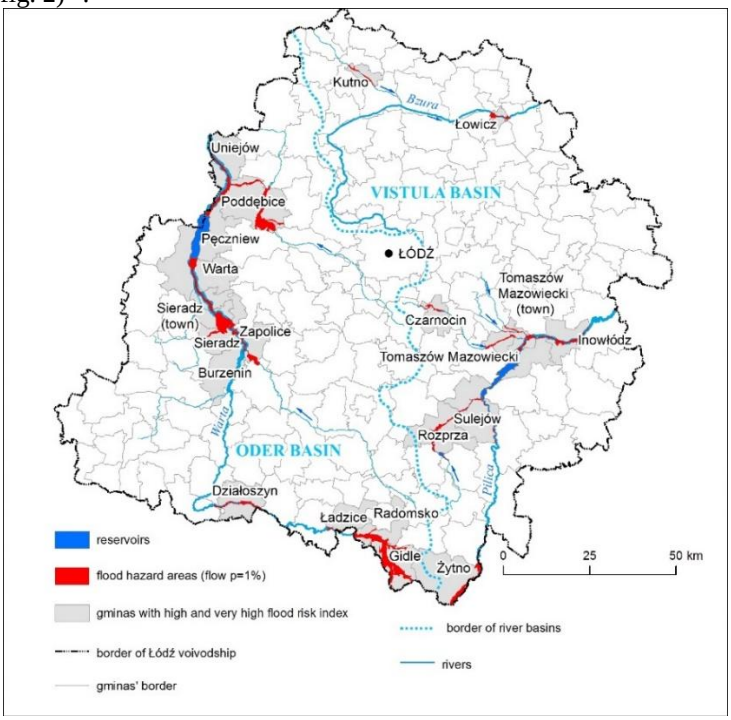

Fig. 2. Flood-prone areas in the researched communes of the Łódź province with high or very high flood risk levels
Source: own work on the basis of *Flood Protection Operating Plan…*(2013), data from the Regional Water Management Board (RZGW) in Poznań and Warsaw and Office for Spatial Planning of the Łódź Province (BPPWŁ) (Borowska-Stefańska 2015e).

The largest areas of 100-year water in terms of their surface (table 2) can be found in rural or rural and urban communes, while the smallest are ocated in urban communes, on smaller rivers or in places with existing levees. In the communes of Poddębice and Gidle the percentage of flood plains in the total reservoir surface of all communes is the largest and amounts to about14%, while in Kutno and in the communes of Ładzice and Czarnocin it reaches a mere 1%. Considering this issue, however, it is the percentage of flood-prone areas in relation to the given community's area that is of utmost importance. In particular in urban as well as rural and urban communes flood-prone areas constitute a considerable part of their surface, which is why an introduction of an absolute ban on development on these areas would lead to a reduction in their growth. In the commune of Gidle the participation of flood plains in the commune surface is about 40%, whereas in the remaining communes it does not exceed 20%[29].

[28]M. Borowska-Stefańska, 2015c, *op. cit.*, p. 8.
[29]M. Borowska-Stefańska, 2015c, *op. cit.*, p. 55.

Table 2. The size of flood-prone areas in the researched communes of the Łódź province

River basin	Gminas	Flood hazard areas	
		totalsurface (ha)	participation of areas particularly exposed to the risk of flooding in the commune in relation to their surface in total (%)
Warty	Gidle	3 625,09	39,27
	Radomsko	1 242,42	14,61
	Ładzice	189,45	2,29
	Działoszyn	726,09	6,05
	Burzenin	690,68	5,84
	Zapolice	953,63	11,79
	Sieradz (ruralgmina's)	2 513,11	13,83
	Sieradz (town)	740,17	14,44
	Warta	1 919,37	7,6
	Pęczniew	2 278,94	17,97
	Poddębice	3 671,87	16,4
	Uniejów	729,42	6,07
Pilicy	Żytno	969,48	5,19
	Rozprza	902,27	5,53
	Sulejów	1 022,29	5,43
	Czarnocin	321,67	4,49
	Tomaszów Mazowiecki (ruralgmina's)	1 583,8	10,47
	Tomaszów Mazowiecki (town)	761,59	18,33
	Inowłódz	828,40	8,49
Bzury	Kutno	292,6	8,59
	Łowicz	396,24	16,91
Suma		26 358,57	–

Source: own work on the basis of data from the Regional Water Management Board (RZGW) in Poznań and Warsaw and Office for Spatial Planning of the Łódź Province (BPPWŁ), 2012; Borowska-Stefańska 2015c, p. 56.

4. RESULTS AND DISCUSSION

Flood-prone areas in the researched communes are dominated by agricultural land areas which occupy about 62% of the catchment area (46% - grassland, 16% - arable land), water areas – 20%, forests – 16%. The percentage of the remaining forms of land use does not exceed 1% (fig. 3), out of which the largest area is occupied by housing development – 0.87% (predominantly single-family residential buildings).

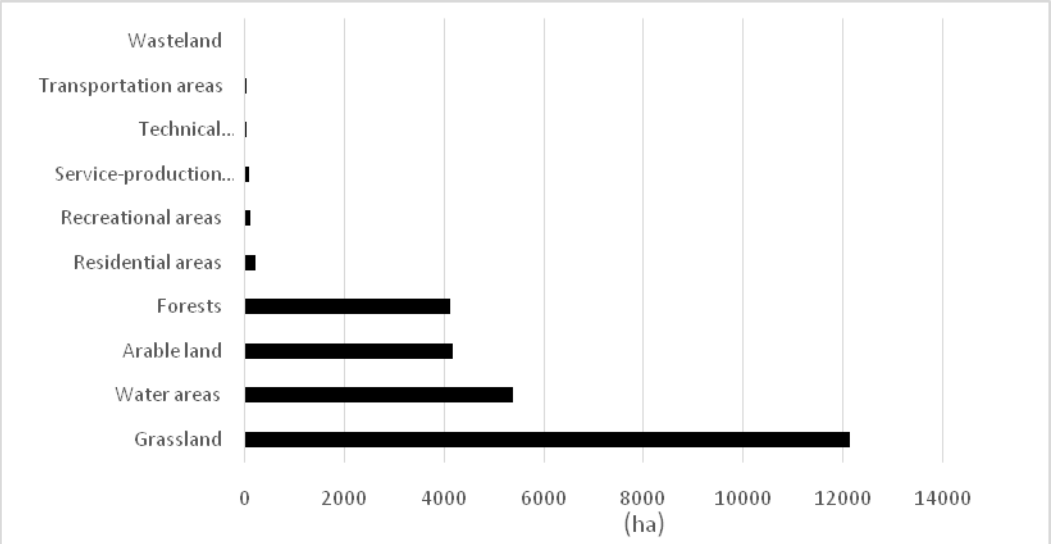

Fig. 3. Land use within flood hazard areas of Łódź region
Source: own study, 2015.

Subsequently individual forms of land use was scrutinized in all the communes within flood plains. Grassland occupies the largest surface in the communes of Gidle and Poddębice, where it takes up 73% and 65% of flood-prone areas respectively. The largest surface of arable land on the flood plains was inventoried in the commune of Sieradz (51% of the area of the so-called 100-year water). Water areas tend to dominate in the communes of Pęczniew and Warta, which is connected with the existence of the Jeziorsko reservoir (they occupy 83% and 65% of flood-prone areas respectively). The largest area of service and production development (5%) and technical infrastructure (5%) was inventoried in Tomaszów Mazowiecki, which differs considerably from the remaining communes in relation to the use of areas particularly exposed to the risk of flooding. Above the town there is a reservoir, which makes the users of flood plains safe and this results in the development of these areas. In Uniejów there is the largest surface of recreation areas (5%), which is also connected with the existence of a water reservoir above the commune (Jeziorsko). In Gidle there is the largest surface of residential and consequently transportation areas (due to participation of flood plains in the commune's area at the level of 40%) (fig.4) as well as forests. Tomaszów Mazowiecki (town) has the highest potential volume of financial losses on flood-prone areas in the researched communes – 303,630.7 thousand PLN, followed by the communes of Gidle – 92,060.39 thousand PLN and Poddębice – 49,186.97 thousand PLN (fig. 5).

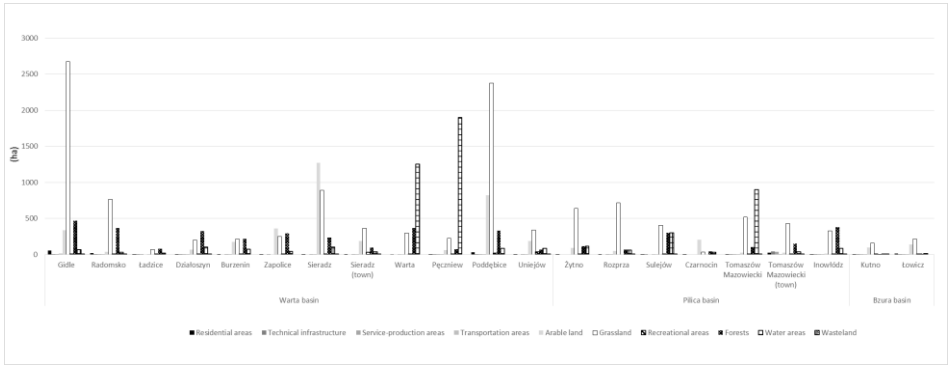

Fig. 4. Land use within flood hazard areas in surveyed gminas of Łódź region
Source: own study, 2015.

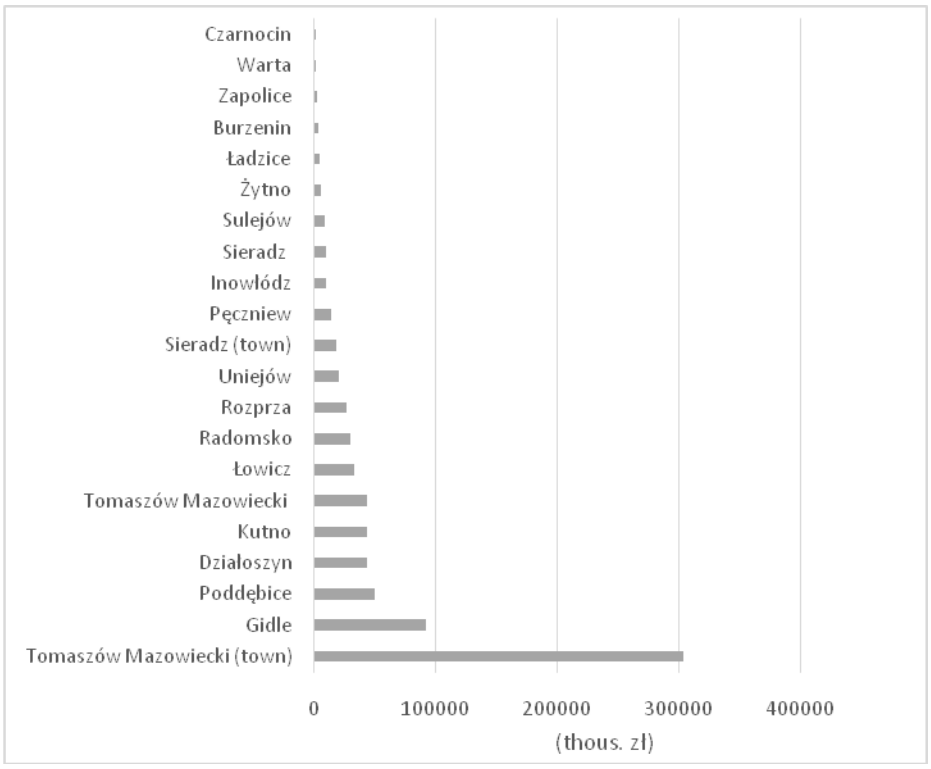

Fig. 5. Potential material losses in gminas of Łódź region
Source: own study, 2015.

In the case of Tomaszów Mazowiecki this is largely due to a considerable surface of built-up areas, mainly technical infrastructure and service and production areas within

flood plains which generate the highest losses. The amount of accumulated property on the analysed areas in the communes of Gidle and Poddębice is a result of existence of single-family residential areas within their boundaries. This is also influenced by the size of flood-prone areas, which is the highest in the scrutinized communes.

In Tomaszów Mazowiecki the highest losses within the flood plain are generated by technical infrastructure areas (141,163.53 thousand PLN) which include (table 3): an electrical substation, a water purification plant and a sewage pumping station. The water purification plant takes up the largest surface in this group as it is located in a spot where smaller rivers (the Czarna and Wolbórka) debouch to the Pilica river, due to which the flood plain there is the widest. Residential areas generate approximately 9% of the total volume of losses on flood plains in the town. They comprise single-family buildings located mainly along the rivers of Czarna and Piasecznica (82 buildings) as well as the Wolbórka(59 buildings). Service and production areas also generate the highest losses in Tomaszów Mazowiecki (among the researched communes). Production companies together with storage areas or warehouses belonging to them are located mainly in the northern part of town (the rivers of Czarna and Piasecznica). They deal with production of crisps (Frito Lay, Ice Full), ceramic tiles (Paradyż Sp. z o.o.), footwear (Comfort Shoes) and car accessories (Polytec Interior). The flood plain area is also home to 3 schools (Upper-Secondary School Complex no. 5, Non-School Facility Complex and School Complex in Komorów which is partly located within the town boundaries as well as numerous service outlets (including furniture shops such as HALIDOR or JYSK)[30].

In the commune of Gidle the highest potential financial losses in the event of flooding are generated by residential areas - 59,472.04 thousand PLN, services and production – 23,302.24 thousand PLN and transportation – 5,573.02 thousand PLN. In Gidle on the flood plain single-family residential development was inventoried. It is located mainly in the southern part of the research area in Borowa, Zabrodzie and Skrzypiec as well as on the left bank of the Warta river in Ruda, Górki and Gowarzów. Service and production areas include, among other things, 3 grocery shops (in Gowarzów and Borowa), a fire station (on the right bank of the Warta river), the Church of the Blessed Virgin Mary of Sorrows, a district hospital (in Radomsko, branch in Pławno, treatment of tuberculosis and lung diseases)[31].

In the commune of Poddębice the highest potential financial losses on the flood plain are generated by built-up areas, including: residential areas – 33,260.64 thousand PLN, service and production areas – 6,643.47 thousand PLN and technical infrastructure ones – 4,525.77 thousand PLN. Single-family residential buildings are mainly located on the flood plain of the rivers of Pisia and Ner in StaryPudłów and NowyPudłów, Pudłówek and Feliksów)[32]. Technical infrastructure areas there comprise a water purification plant situated on the right bank of the Ner in the northern part of the commune. Furthermore, Maria Konopnicka Secondary School in Poddębice, a town fair, a building belonging to a local hunting club were inventoried on the flood plain there.

[30]M. Borowska-Stefańska, 2015c, *op. cit.*, p. 76.
[31]*Ibidem*, s. 68.
[32]*Ibidem*, s. 70.

Table3. Potential material losses within flood hazard areas in the surveyed gminas of Łódź region

River basain	Gminy	Potential material losses (thous. zł)							
		Residential areas	Technical infrastructure	Service-productionareas	Transportationareas	Arable land	Grassland	Recreationalareas	Forests
Warta basin	Gidle	59472,04	1376,55	23302,24	5573,02	478,72	1801,99	18,28	37,55
	Radomsko	22968,56	170,49	2357,38	3525,53	57,22	516,65	150,00	29,42
	Ładzice	686,15	2776,69	885,14	-	13,70	50,01	11,39	6,53
	Działoszyn	11250,93	4069,87	26506,38	1162,48	100,64	134,95	105,85	26,00
	Burzenin	1380,97	-	989,44	301,94	248,24	145,15	190,46	17,53
	Zapolice	2,63	-	1303,17	0,00	513,11	169,65	18,64	23,86
	Sieradz	6809,15	-	456,71	49,84	1816,61	600,65	40,93	18,92
	Sieradz (town)	7576,24	-	6236,14	2304,25	268,33	244,05	1705,66	8,06
	Warta	0,09	1018,84	0,00	218,01	1,14	201,80	7,24	29,30
	Pęczniew	8348,07	3444,55	345,03	1107,52	89,00	152,76	78,28	5,98
	Poddębice	33260,64	4525,77	6643,47	926,95	1171,66	1603,13	1029,01	26,36
	Uniejów	2517,74	-	14407,27	221,78	270,85	227,84	1937,31	5,66
Pilica basin	Żytno	4658,71	-	0,00	0,00	129,08	431,14	1,39	9,43
	Rozprza	4332,80	-	21468,65	242,50	69,66	481,93	-	5,26
	Sulejów	2897,10	4956,71	0,00	170,24	6,62	273,50	158,26	24,05
	Czarnocin	618,11	-	0,17	0,00	292,40	22,96	-	3,75
	Tomaszów Mazowiecki	11350,88	10476,52	18840,15	1979,62	37,52	352,00	9,68	8,56
	Tomaszów Mazowiecki (town)	27517,50	141163,53	132252,21	2352,76	34,91	289,30	8,11	12,39
	Inowłódz	6006,93	182,37	2673,87	382,09	19,85	220,67	497,51	30,43
Bzura basin	Kutno	9658,18	1020,98	30135,34	1941,41	137,85	109,81	181,87	0,20
	Łowicz	12187,26	9972,45	9404,63	865,15	196,52	143,15	21,57	0,99

5. CONCLUSIONS

Analysis of the current land development showed that in the event of flooding the highest potential property losses on flood-prone areas will occur in Tomaszów Mazowiecki and then in the communes of Gidle and Poddębice. This mainly due to horizontal intensity of use of flood plains and the surface of the flood plain area. The highest potential losses in Tomaszów Mazowiecki are generated by service and

production buildings as well as the water purification plant while in the commune of Gidle these are single-family residential buildings, service and production areas as well as transportation areas. In Poddębice, in turn, floods may affect both residential development, service and production buildings as well as the water purification plant.

On the analyzed areas buildings are mainly located in those places where the flood plain is wide and on flood plains of smaller rivers, such as the rivers of Czarna, Piasecznica or Pisia. Due to losses caused by floods in recent years it is necessary to assess potential financial losses in a plausible way. The method presented in this work has its application especially on areas where floods do not cause huge losses and there are no detailed data about its consequences from the historical perspective. It is possible to draw conclusions about risk levels on the basis of current land development, which is particularly important in implementing an adequate flood protection policy[33].

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OCENA STRAT MATERIALNYCH NA TERENACH ZAGROŻONYCH POWODZIAMI W WOJEWÓDZTWIE ŁÓDZKIM

Celem badań jest ocena aktualnego stanu zagospodarowania terenów zagrożonych powodziami ze względu na potencjalne straty materialne, na przykładzie 21 gmin województwa łódzkiego, które uzyskały duży lub bardzo duży poziom ryzyka powodziowego w metodologii wykorzystanej w *Planie operacyjnym ochrony przed powodzią dla województwa łódzkiego*[34]. Za teren zagrożony powodzią, przyjęto teren szczególnego zagrożenia powodzią, na którym prawdopodobieństwo wystąpienia powodzi jest średnie i wynosi 1%[35]. Oceny strat materialnych dokonano zgodnie z wytycznymi zawartymi w *Rozporządzeniu Ministra Środowiska, Ministra Transportu, Budownictwa i Gospodarki Morskiej, Ministra Administracji i Cyfryzacji oraz Ministra Spraw Wewnętrznych z dnia 21 grudnia 2012 r. w sprawie opracowywania map zagrożenia powodziowego oraz map ryzyka powodziowego*[36]. Potencjalne straty materialne obliczono na podstawie analizy zagospodarowania terenów zagrożonych powodziami, przy wykorzystaniu Topograficznej Bazy Danych oraz inwentaryzacji terenowej. Za pomocą metod GiS przedstawiono zarówno zagospodarowanie, jak ocenę strat. Stwierdzono, że w granicach terenów szczególnego zagrożenia powodzią najwyższe straty materialne są w Tomaszowie Mazowieckim, Łowiczu i Kutnie co jest związane z istnieniem terenów usługowo-produkcyjnych i mieszkaniowych. Analiza poziomu ryzyka powodziowego jest bardzo ważna, gdyż umożliwia ona prowadzenie odpowiedniej polityki w zakresie ochrony przeciwpowodziowej[37].

Słowa kluczowe: tereny zagrożone powodziami, straty materialne, mapy zagrożenia i ryzyka powodziowego, GIS.

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