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URBAN PLUVIAL FLOOD RISK IN ROMANIA, IN THE CONTEXT OF FLOODS DIRECTIVE IMPLEMENTATION

T. SAMPSON[1], D. RĂDULESCU[1], M.B. ION[1], A. COZMA[1]

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ABSTRACT. ***Urban Pluvial Flood Risk in Romania, in the Context of Floods Directive Implementation.*** Romania is a flood prone country and same are her cities. Pluvial floods can occur in urban or rural areas without a direct connection with river or a water body. As part of the Floods Directive implementation, Romania has identified, in the first cycle, a number of 17 urban areas with a significant pluvial flood risk potential. For every urban area identified, flood hazard and flood risk maps have been developed. Based on this, the present paper tries to present some of the main risk receptors, that could give an insight related to the level of risk at which the urban areas are exposed. What is the quantitative risk profile of this cities, what can be done further to mitigate this risk and are there any other urban areas at risk of pluvial flooding? The present paper seeks to provide an answer at the above questions and present potential solutions for pluvial risk reduction.

Keywords: Pluvial urban floods, risk mitigation, floods directive, Romania

1 INTRODUCTION

Floods can arise from a variety of causes. The best understood floods occur when, following intense or prolonged rainfall, water levels in rivers rise and the rivers overtop their banks (fluvial flooding). Also, well defined are coastal floods caused by storm surges and wave action superimposed on high water levels generated during the diurnal cycle of tides (Ball et al., 2008).). Flooding can also occur from ground water rising to the surface of the land, usually associated with prolonged periods of heavy rainfall.

Less well understood by the general public are pluvial floods which often occur unexpectedly in locations not obviously prone to flooding and with minimal warning – hence the term an invisible hazard' (Houston, 2011).

A common misconception about flood is that you must be located near a body of water to be at risk. But a pluvial flood can happen in any location, urban or rural; even in areas with no water bodies in the vicinity.

A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body. There are two common types of pluvial flooding (*The threat from above: pluvial flooding*, 2019):

- *Surface water floods* occur in areas not previously associated with natural or manmade water courses (Working Group Floods, 2010), when an urban drainage system is overwhelmed and water flows out into streets and nearby

[1] JBA Consult Europe, Email: tom.sampson@jbaconsulting.com, daniela.radulescu@jbaconsulting.ro, bogdan.ion@jbaconsulting.ro, andrei.cozma@jbaconsulting.ro

structures. Surface water occurs gradually, which provides people time to move to safe locations, and the level of water is usually shallow (rarely more than 1 meter deep). It creates no immediate threat to lives but may cause significant economic damage;

– *Flash floods* are characterized by an intense, high velocity torrent of water triggered by torrential rain falling within a short amount of time within the vicinity or on nearby elevated terrain. They can also occur via sudden release of water from an upstream levee or a dam. Flash floods are very dangerous and destructive not only because of the force of the water, but also the hurtling debris that is often swept up in the flow (*Three common types of floods explained*, 20th April 2023).

Depending on the location and local setting, pluvial flooding can also be combined with river flooding or coastal flooding. When this happens, promoting sustainable flood management becomes an even bigger challenge (Figure 1) (Scottish Government, 2010).

In this respect different definitions have been attributed to pluvial floods:

– flooding as a result of rainfall when water ponds or flows over the ground before it enters a natural or man-made drainage system or watercourse, or when it cannot enter because the system is already full to capacity (SEPA, Improved Understanding of Pluvial Flood Risk, 2009);

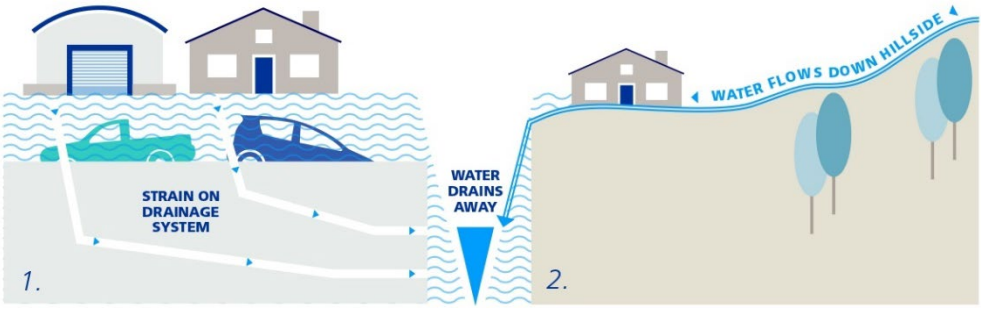

Fig. 1 ***Examples of pluvial floods:***
1) Intense rain saturates an urban drainage system, 2) Run-off or flowing water from rain falling on elevated terrain, e.g. hillsides, that are unable to absorb the water. Source The threat from above: pluvial flooding, 2019)

– flooding of land directly from rainfall water falling on, or flowing over, the land This source could include urban storm water, rural overland flow or excess water, or overland floods arising from snowmelt (European Commission, 2013);
– flooding caused by precipitation on the surface, not connected to river (Report *Workshop pluvial floods*, Berlin, 2016);
– pluvial flooding goes into the river, fluvial flooding comes out of the river (Report *Workshop pluvial floods*, Berlin, 2016);

– flooding that takes place from the 'surface runoff' generated by rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not yet entered a watercourse, drainage system or public sewer (*What is the Risk of Flooding from Surface Water map?*, 2019).

2 CAUSES OF PLUVIAL FLOODS

Pluvial/surface water flooding occurs when heavy rainfall saturates drainage systems and creates a flood independent from a body of water, but its outflow will eventually enter a fluvial system or network.

The expansion of impermeable surfaces in the urban environment increases the surface water flows in sewers, and climate change is likely to exacerbate this problem. This increases the risk of systems overloading in sustained rainfall events and potentially causes pollution of watercourses when combined sewer overflows. By transferring water rapidly away from where it falls there is also the possibility of a receiving watercourse being inundated and causing flooding (*Surface water (pluvial) flooding*, Local Government Association) (Figure 2).

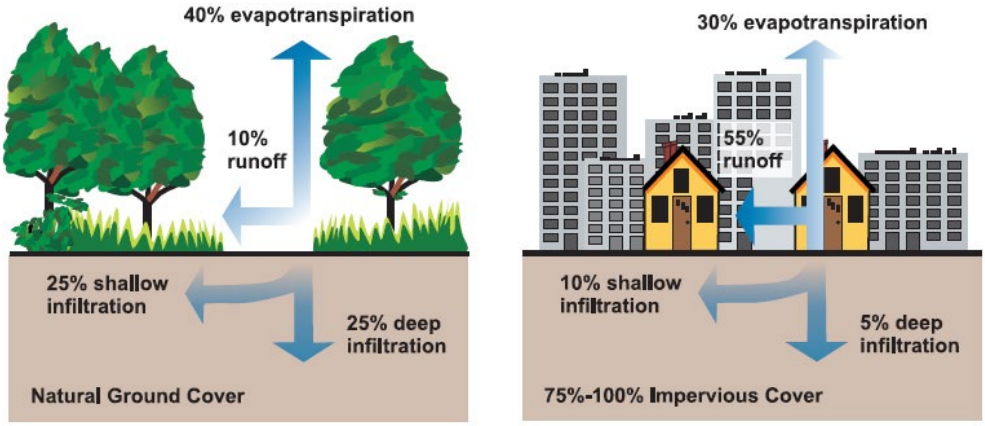

Fig. 2 ***Different urban and rural processes, that influence the pluvial flood***

3 FLOODS DIRECTIVE - FRAMEWORK FOR MANAGING FLOODS CONSEQUENCES

The implementation of *Directive 2007/60/CE on the assessment and management of flood risks* (commonly known as Floods Directive) requires all Member States to go through three stages, the process being cyclical, updating/ reviewing and reporting to the European Commission on each stage every six years:

– First stage – **Preliminary flood risk assessment** – involves nationwide identification of significant historical floods and potential future significant floods (in terms of recorded/potential damage) and delineation of areas with

significant potential flood risk (*Areas with Potential Significant Flood Risk – A.P.S.F.R.*, 526 delineated areas in Romania);

- Second stage – **Development of hazard maps and flood risk maps** for APSFRs (delimited in the previous step) under different flood scenarios;
- Third stage – **Elaboration of Flood Risk Management Plans** for all 11 Water Basin Administrations as well as for the Danube River, based on the above mentioned maps; the 12 Plans include proposals for flood risk reduction measures for APSFRs defined in first stage of Floods Directive 2007/60/CE implementation).

The Floods Directive 2007/60/CE requires the Member States to report floods analysed from 3 points of view: source, mechanism and characteristics (figure 3). The list of types of floods were prepared with the purpose to facilitate reporting under all stages of the Floods Directive, as well as to facilitate the analysis of the information.

The descriptions for each of the terms used the define the floods, are included in the *Guidance Document No. 29 A compilation of reporting sheets adopted by Water Directors Common Implementation Strategy for the Water Framework Directive (2000/60/EC)* to ensure a common understanding of the terms used for reporting purposes, and do not entail legal definitions.

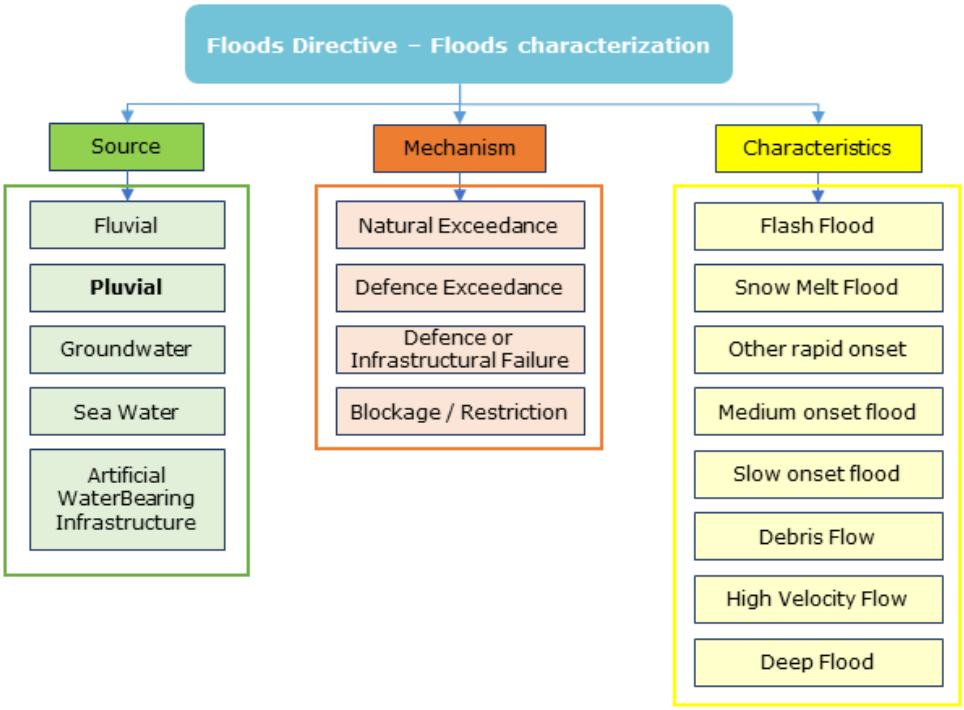

Fig. 3 ***Floods characteristics according to Floods Directive***

As we can see in Figure 3, for example a flood can have the source set as pluvial (or any other source from the ones mentioned in the source column), Blockage /

Restriction as a main mechanism and flash flood as a main characteristic, but pluvial floods (as any other flood) can be associated to multiple any other characteristics and mechanisms.

During the second cycle of Floods Directive, the Competent Authority National Administration "Romanian Waters" (Preliminary Flood Risk Assessment, INHGA, 2019) has identified 17 APSFRs with significant pluvial flood risk, covering 19 municipalities and cities: Reșița, Caransebeș, Oțelu Roșu, Timișoara, Petroșani, Caracal, Pitești, Ploiești, Cernavoda, Corbu, Tulcea, Constanta (including Eforie and Costinești), Cluj-Napoca, Zalău, Roman, Suceava, Gura Humorului. The distribution across Romanian territory is being presented in Figure 4.

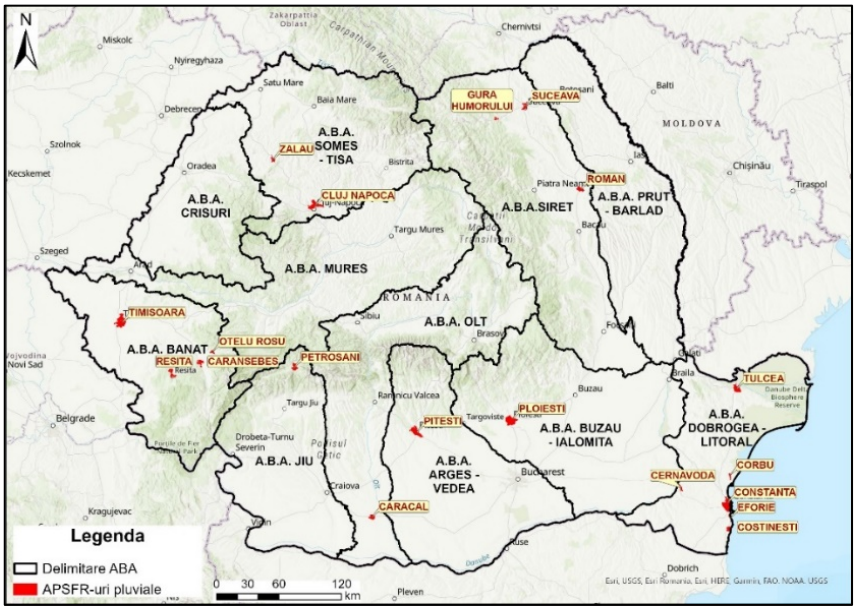

Fig. 4 ***Distribution of pluvial APSFRs in Romania***

The present article is analysing the 19 municipalities and cities, urban areas, subject to pluvial floods that can occur due to heavy precipitations.

4 URBAN PLUVIAL FLOOD RISK

In order to support implementation of the 2nd cycle of Floods Directive in Romania, inside the framework of the RO-FLOODS application (Strengthening the capacity of the central public authority in the water field in order to implement the 2nd and 3rd stages of the 2nd Cycle of the Floods Directive, SIPOCA code 734), the Ministry of Environment, Water and Forests as main beneficiary, signed with the World Bank, a Reimbursable Technical Assistance Agreement for the elaboration of Flood Risk Management Plans for Romania.

Subsequently to this contract, following a competitive tender, the World Bank awarded the consortium led by JBA Consulting (UK / Ireland / Romania) - project

leader, together with partners HKV (Netherlands), DHI (Denmark / Romania) and Aquaproiect (Romania), the consultancy contract entitled "Consultancy services for the preparation of hazard and flood risk maps and Flood Risk Management Plans for Romania". As part of the afore mentioned consulting contract, JBA produced the first national-scale flood hazard and risk maps for the pluvial source for 17 APSFRs

To obtain the hazard maps, JBA built 19 HEC-RAS 2D hydraulic models for which very high accuracy data were used: 0.5m resolution DTM, Intensity-Duration-Frequency curves updated at the time of the project, assumptions on the sewer networks in order to integrate them into the models, database of recorded historical floods for model validation, which finally led in the end to high confidence results and hazard maps (Figure 5).

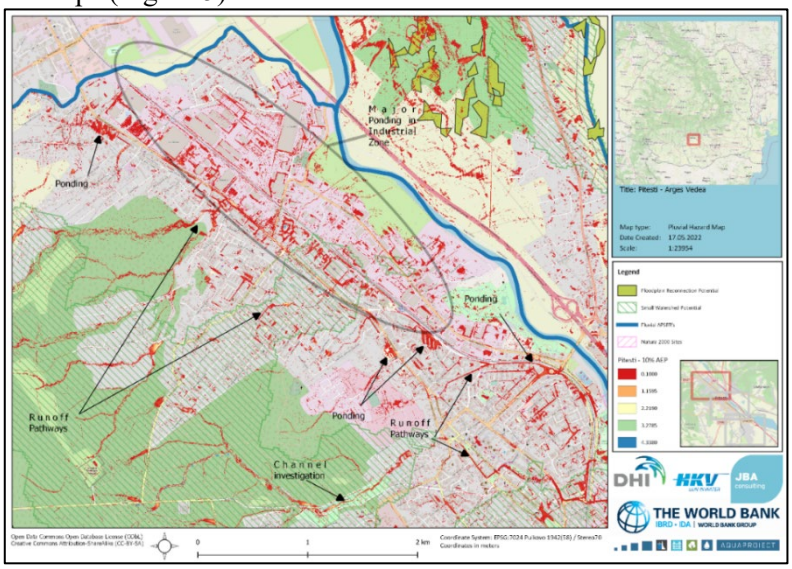

Fig. 5 ***Example of pluvial hazard map reported to European Commission (Source: https://harticiclul2.inundatii.ro/map)***

Based on the hazard maps, pluvial risk maps were built for the same 17 APFSRs (respectively 19 municipalities and cities), which are also the first hazard and risk maps of this type produced on a national scale and reported to the European Commission for Romania. The methodology that supported the development of flood risk maps can be consulted on website https://inundatii.ro/. Example of flood risk map developed is provided in Figure 6. The following risk metrics are provided for the pluvial floods with returns periods of 1 to 100 years.

One of the most important social risk metrics is the population flooded. The statistical indicators reveal that in case of pluvial floods with returns periods of 1 to 100 years the most affected town will be Timisoara, followed by Constanta and Tulcea. In the Figure 7 Affected population by pluvial floods at urban area level - compared scenarios with and without climate change influence can be observed the population affected by pluvial floods at the level of each one of the 19 municipalities and cities. The figure presents also the potential affected population in the scenario

of pluvial floods with Climate Change. The less affected urban areas are Roman, Otelu Rosu si Corbu.

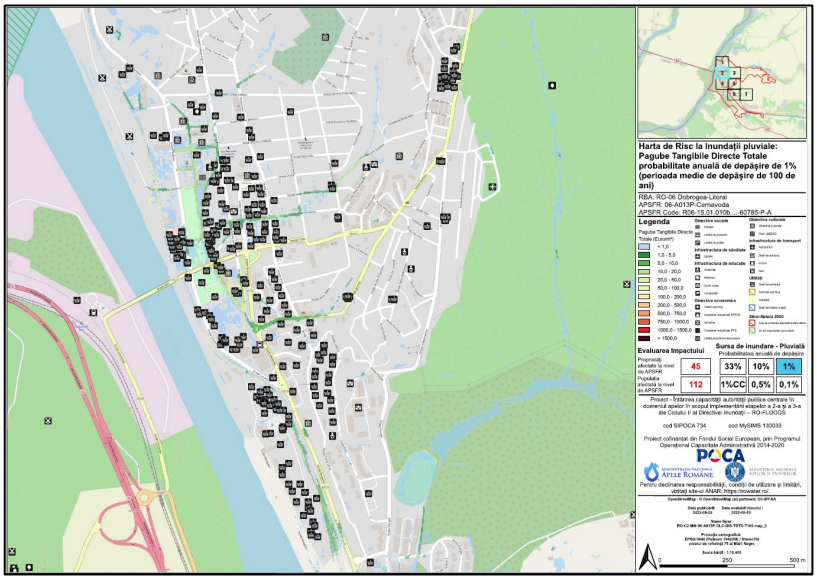

Fig. 6 ***Example of pluvial risk map reported to European Commission (Source: https://harticiclul2.inundatii.ro/map***

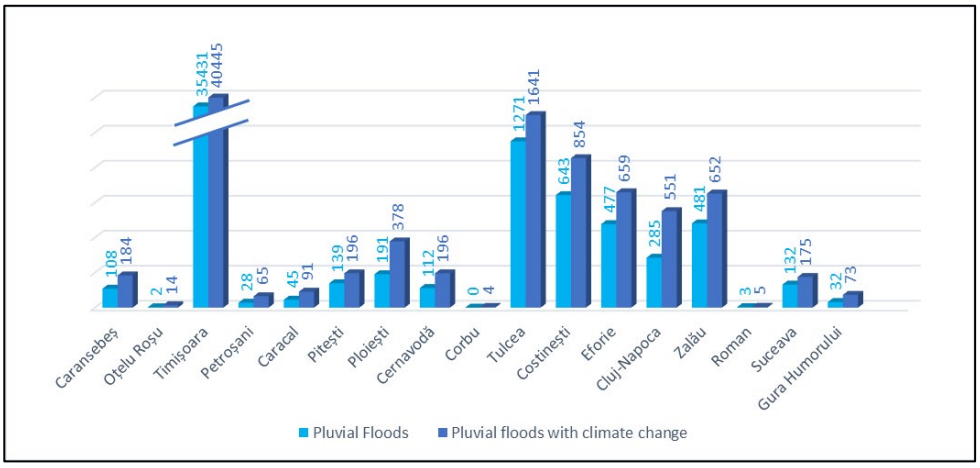

Fig. 7 ***Affected population by pluvial floods at the level of 19 municipalities and cities - compared scenarios with and without climate change influence***

It is important to mention that from the perspective of pluvial floods impact over the community, respectively the share of population affected by floods, in relation with the total population of the urban area, Costinesti is the most affected (20.60%), followed by Timisoara (14,12 %), Constanta (5,55%), Eforie (5,53%) and Tulcea (1,94%).

Affected domestic properties is one of the most important components when estimating the economic impact of pluvial floods. Due to the high density of properties Timisoara is one of the most affected cities, followed by Constanta, Tulcea and Costinesti (Table 1)

Table 1 ***Affected Properties by pluvial floods at the level of the 19 municipalities and cities***

Urban Area Name	No of Properties	Urban Area Name	No of Properties
Timișoara	17.506	Reșița	76
Constanța	6.424	Caransebeș	55
Tulcea	685	Cernavodă	45
Costinești	646	Caracal	30
Eforie	362	Gura Humorului	27
Zalău	338	Petroșani	18
Cluj-Napoca	163	Roman	2
Suceava	99	Oțelu Roșu	2
Ploiești	93	Corbu	0
Pitești	77		

In order to better understand the impact of the pluvial floods over the urban areas, it has been calculated the share of flooded area from the total urban area and we have observed that the area flooded is not bigger than 17,5%. The most affected being Caransebes (17,5%), followed by Costinesti (16.13%), Tulcea (15,9%), Pitesti (13,43%)

The total tangible direct damages caused by pluvial floods over the 19 municipalities and cities was estimated at around 127.441.962 Euro. The share of each type of damages from the total damages value is presented in Figure 8.

CONCLUSIONS AND FURTHER ACTIONS FOR PLUVIAL RISK MITIGATION

After development of Flood hazard and risk maps has been done, for each of the 17 APSFRs JBA has developed a factsheet describing the following information: location, identification flood hazard, data quality assessment and description of strategy for pluvial flood risk mitigation. One of the core measures proposed, included in the Flood Risk Management Plans developed at the level of each River Basin Administration, is the development of Pluvial Flood Risk Management Plan at the level of municipalities and cities analysed.

JBA Consult Europe together with Ramboll South East Europe and INCDS "Marin Dracea" (subcontractors of JBA Consulting) signed a contract for consulting and expertise services with Ministry of Environment, Water and Forests for revising and updating the National Strategy for Long-Term Flood Risk Management and the Implementation Plan. The revised version of the Strategy, posted for public consultation in December 2023, according to *Chapter XI Budgetary implications and sources of funding*, is foreseeing: ”Therefore, it is proposed that the content of the

local development strategy, prepared by local authorities, should include an analysis of the risk of pluvial flooding and the identification of appropriate flood risk management measures (part of the Pluvial Flood Risk Management Plan). The framework content of the Pluvial Flood Risk Management Plan will be approved through a Order of the central public authorities in the field of Water Management and Spatial Planning. Pluvial Flood Risk Management Plan must be integrated into Flood Risk Management Plans, in line with the basin-wide strategic vision outlined by them".

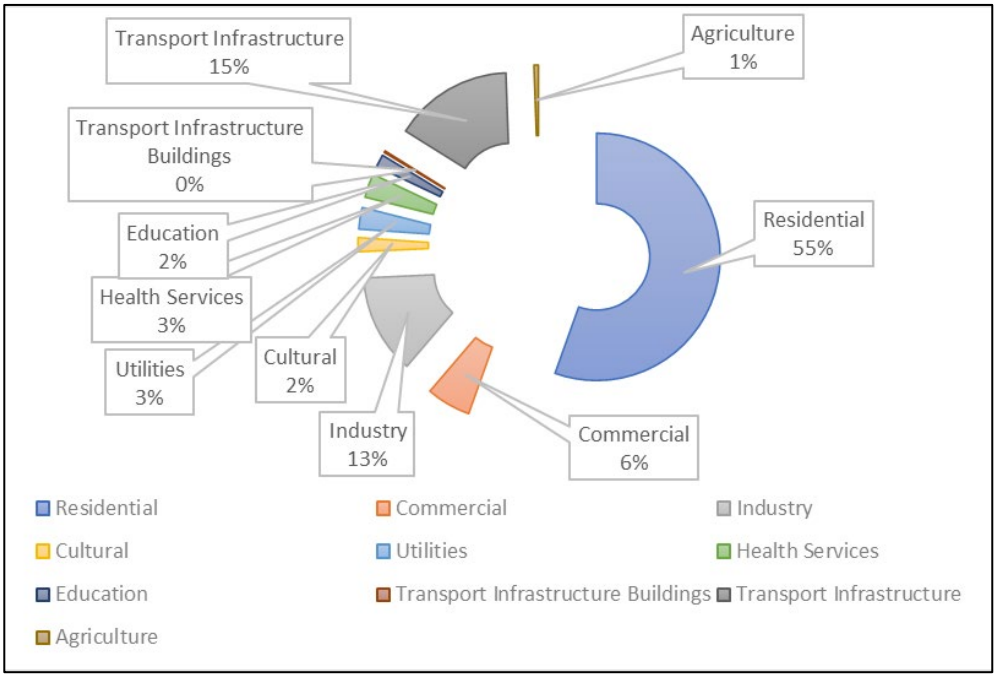

Fig. 8 ***Share of each type of damages caused by pluvial flooding at the level of the 19 municipalities and cities***

Further assessment for identification of new other APSFRs with Pluvial risk will need to continue under the first stage of Floods Directive (Preliminary Flood risk Assessment) as part of the 3rd cycle of Implementation.

Therefore, development of Pluvial Flood Risk Management Plans followed by implementation of the main outcome of the plan (measures and strategies) will be the first steps needed to be taken to reduce the pluvial flood risk. This will only be achieved through involvement of local authorities, utility companies, water management and spatial planning experts.

REFERENCES

1. Ball, T., Werritty, A., Duck, R. W., Edwards, A., Booth, L. and Black, A. (2008) Coastal Flooding in Scotland: A Scoping Study. Report to SNIFFER, Edinburgh
2. Houston, D., Werrity, A., Bassett, D., Geddes, A., Hoolachan, A. and McMillan, M. (2011). Pluvial (rain-related) flooding in urban areas: the invisible hazard Project Report. Joseph Rowntree Foundation.
3. European Commission (2013), Directorate-General for Environment, A compilation of reporting sheets adopted by water directors common implementation strategy for the Water Framework Directive (2000/60/EC). Guidance document No 29, European Commission, https://data.europa.eu/doi/10.2779/50095
4. Working Group Floods (2016) Report Workshop pluvial floods of EU-COM, Berlin
5. Working Group Floods (2010), Thematic Workshop: Flash Floods and Pluvial Flooding, Report on Proceedings & key recommendations, Cagliari, Italy
6. *** (2023) Revised National Flood Risk Management Strategy for the medium and long term
7. *** (2023) River Basin Administration Flood Risk Management Plans, https://inundatii.ro/resurse/
8. *** (2023) *Surface water (pluvial) floodin*g, Local Government Association https://www.local.gov.uk/topics/severe-weather/flooding/flood-and-coastal-erosion-risk-management/surface-water-pluvial
9. *** (2023) Three common types of floods explained, article , 20th April 2023, https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood
10. *** (2023) Various deliverables that supported the development of Revised National Flood Risk Management Strategy for the medium and long term, JBA Consult Europe
11. *** (2020), *The threat from above: pluvial flooding*, Online Article, https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/the-threat-from-above
12. *** (2019) *What is the Risk of Flooding from Surface Water map?*, Report version 2.0 https://assets.publishing.service.gov.uk/media/5db6ded540f0b6379a7acbb8/What-is-the-Risk-of-Flooding-from-Surface-Water-Map.pdf
13. *** (2019) Preliminary Flood Risk Assessment, INHGA, 2018, https://www.hidro.ro/evaluarea-preliminara-a-riscului-la-inundatii-rapoarte/
14. *** (2011), Flood risk management (Scotland) act. Delivering sustainable flood risk management - a consultation, ISBN 9780755999279
15. *** (2009) *Improved Understanding of Pluvial Flood Risk in Scotland,* SEPA