THE APLYING OF "SOCIAL EFICENCY" IN DESIGNING THE AUTOMATIC NETWORK FOR THE WARNING OF POPULATION

Ph. Dr. Ion Pasoi

National Institute of Hydrology and Water Management, Bucuresti, Romania,
e-mail: ion.pasoi@hidro.ro

Abstract: The basic targets of the automatic network are: the warning of the inhabited areas over an immediate flood or pollution which has an important risk of affecting lives, hydrological forecast, water management at hydrological basin level. The warning of people to immediate flood results in their evacuation together with their assets.

The warning is made by recording levels/discharge upstream which can cause a flood downstream after a time (T_{es} – warning estimated time). A warning is efficient if $T_{es}>T_{esn}$ (minimum necessary time for an efficient warning)

For the design of an automatic network for warning, we propose the "Social efficiency method. For this method we shall apply the function Z=C/E (where C= total costs, E = social effect expression). By "social effect expression" we understand the number of inhabited areas/families warned.

The methods for determining the potential number of the families which can be evacuated after the warning of immediate flood is given are:

- the identification of the river sector for which the station gauge can be considered as useful for warning. The upstream end of this sector is conditioned by $T_{es}>T_{esn}$. The downstream end is conditioned by the relation $F_{sh}/F_{sav}>0.4$ (F_{sav} river basin area corresponding to the downstream end of the warned river sector, F_{sh} the river basin area corresponding to the hydrometrical station)

* the evaluation of the families number which can be evacuated is made by:

  - drawing the maps with flood risk zones for different probabilities of maximum discharge. (with GIS techniques or topographic plans digitization) and on these the number of houses is identified. It is the most precise method.
  - once specified the potential warned zone, on the basis of maps, the number of inhabited areas which can be flooded is established; the method is relative and is recommended only for orientative evaluations

The paper presents:

- the way of delineating the warned area
- the way of expressing the "social efficiency"; for this we propose the usage of some level/discharge relations with different periods of showing, which cause floods – the number of towns/families warned
  the way of representing the target function towards the decisional factors in order to establish the way the automatic network look like
- a case study from Romania

Keywords: efficiency, warning, automatic station, upstream limit, downstream limit

ANWENDUNG DER METHODE “SOZIALE WIRKSAMKEIT “ ZUM ENTWERFEN DES NETZES DER AUTOMATISCH HYDROMETRISCHEN STATIONEN FÜR DIE WARNUNG DER BEVÖLKERUNG

Kurzfassung: Die hauptsächliche Zweckedes automatisch hydrometrischen Netzes sind: die Warnung der bevölkerten Zonen über die bevorstehenden Überschwemungen und über manche zufällige Wasser Verschmutzung mit grossem Risiko, hydrologische Voraussagung, und Bewirtschaftung der Wasserressoursen eines Einzugsgebiet. Die Aufstellung der automatischen Stationen wird regelmässig in dem Querschnitt einer vorhandenen Mess-Station vollbracht. Die Warnung wird durchgeführt nach der Aufnahme von Hochwasserständen(Durchflüsse), in stromaufwärts liegenden Mess-Stationen, welche abwärts nach einer bestimmten zeitfrist T_{es} zur Erzeugung von Überschwemmungen führen können. Man nimmt an eine Warnung sei Wirksam falls $T_{es}>T_{esn}$, wo die Zeitfrist darstellt, für eine wirksame Warnung bei einem Zeitpunkt, als minimal betrachtet.

Für das Entwerfen des automatischen Netzes für Voraussagung und Warnung wird die Methode “Soziale Wirksamkeit” vorgeschlagen.

Für diese Methode wird die Funktion Z= C/E (wo C=total Kosten, E= Ausdruck des Sozialen Faktor) benutzt. Durch Sozial-Faktor wird die Zahl der gewarnten Ortschaften/Familien verstanden.

Das Werk trägt vor:

- Die Art des gewarnten Zone Begrenzung;
- Die Art zum Ausdruck der “sozialen Wirkssamkeit”; dafür wird das Benützen von Gleichungen Wasserstand/Durchfluss bestimmt mit verschieden überschreitungs Warscheinlichkeiten, welche Überschwemmungen verursachen können-Zahl der gewanten Ortschaften/Familien.
- Ausdruck des Eingreifen Indikators;
- Der Wert des Beschädigungsgrad;
- Die räumliche Verteilung mittels Landkarten.

Am Ende wird ein Studium-Fall aus Rumänien vorgetragen.

Schlüsselworte: Wirksamkeit, Warnung, automatisch hydrometrischen Stationen, oberliegend, unterhalb

1. Introduction

The basic targets of the automatic network are: the warning of the inhabited areas over an immediate flood or pollution which has an important risk of affecting lives, hydrological forecast, water management at hydrological basin level. The warning of people to immediate flood results in their evacuation together with their assets. The automatic stations are usually placed at existing gauging stations.

The warning is made by recording levels/discharge upstream which can cause a flood downstream after a time (T_{es} – warning estimated time). A warning is efficient if $T_{es}>T_{esn}$ (minimum necessary time for an efficient warning).

The T_{esn} time has a dynamic character, and it can take values according to the local warning possibilities and people’s capacity of understanding the phenomena. Now days it is considered that T_{esn} = 3 hours. the warning is valuable for the local communities which respect the time condition mentioned above and which also respect the condition of flood probability. The latter is usually expressed as a ratio between the basin’s area at the gauging station and the basin’s area near the warned community.

The selection of the gauging stations equipped with automated systems for flood or major pollution warning is based on the method called “Social efficiency”. This method allows the hydrotehnical activity analysis, based on efficiency (generally defined as ratio between the expenses with a system and the benefits they offer), which is more than necessary in the conditions of market economy and relatively low economical possibilities.

2.Defining Social Efficiency criteria

The Social Efficiency criteria is expressed by Z_{es} function:

$$Z_{es}=\frac{C}{Es} \qquad (1)$$

Where:

Z_{es} = objective function

C = total costs of the automated station

Es = social efficiency

Social efficiency can be the number of towns within the range of warning area, people that can be evacuated, the value of assets that can be evacuated, etc. The time evolution analysis shows that among them the number of warned towns (N_l) is the one which varies less, as well as the number of warned families (N_{fa}).

Defining efficiency through the social factor instead of defining it through benefits as it has been done so far, eliminates the major difficulty of transforming the benefit into currency.

2.1.The methodology proposed for determining N_l and N_{fa} has the following components:

- The identification of the upstream limit of the river sector for which the warning can be made

  The upstream limit of the warned sector is defined by the condition $T_{es}>T_{esn}$. in this respect it shall be calculated, through known methods, the curves $T_p(Q)$ and $V_m(Q)$, where T_p – the time in which a flood reaches the next gauging station, Q – discharge, V_m – average speed of the flood between two neighbouring gauging stations.

  $$V_m = \frac{L}{T_p} \qquad (2)$$

  Where L= the distance between two neighbouring gauging stations

  The flood's routing time to the nearest gauging station from an inhabited area is:

  $$T_{pl} = \left(\frac{L_{sl}}{L}\right)\times V_m \qquad (3)$$

  Where: L_{sl} = the distance between the upstream gauging station and the section near the inhabited area

  Practically V_m can be considered equal to 1m/s in plain regions, 1.5m/s in hill regions and 2m/s I mountainous regions.

  Taking into account the above mentioned values for V_{im} and T_{esn} = 3h, the following upstream limits of the warned sector where calculated:

  L_{sl} = 11 km for plain regions
  = 16 km for hill regions
  = 22 km for mountainous regions

- The downstream limit for which the warning is efficient is defined as the downstream gauging section for which the ratio between the gauging station's area and the downstream gauging section is less then 0.5.

- The number of potentially warned inhabited areas (N_l) can be evaluated from maps and terrain observations.
- The number of families which can be evacuated can be determined as follows:
  - The discharge value from the gauging station is transmitted to the section near the inhabited area, usually with the aid of the ratio between areas. The discharge is then transformed into river's level, with the aid of a rating curve for floods, hydraulically calculated. Based on the cadastral data of the town the number of families from the area which can be flooded, is calculated. Taking into account that the flooded area depends on the discharge value, choosing the value of the maximum discharge over the years, is the most appropriate. The analysis is made for all the inhabited areas from the warned sector.
  - Flood studies on the river are carried out. In this way the number of families and the area which can be flooded are determined for maximum and average discharge over the years.

  If possible it is strongly recommended to use the latter method as it is more precise and can be also associated with GIS maps. If desired, the method can be applied using more values of the maximum discharge, with different happening probabilities. In this case the value of the objective function Z_{es} will raise together with the increase of the maximum discharge apparition frequency thus raising the importance of the gauging station.

Simplified, the costs of the automatical station can be considered equal, thus social efficiency being calculated based only on E_s . This is highly recommendable, taking into account that the automatical station is used for a variety of purposes. Establishing the maximum value of E_s for which a gauging station is considered efficient for people warning, is a political decision and it belongs to the administrative decision factors at a local and national level.

3.The applying of "Social Efficiency" method for Tutova river basin (a tributary to Barlad river)

Below it is presented a case study using the "Social Efficiency" method for an automatic warning network for a river basin from Romania. (Fig. 1).

Tutova river, a tributary to Barlad river, has an area of 687 km ^{2} and 86 km in length. It has 9 tributaries of 1st degree with areas between 11 and 96 km^2 and lengths between 5 and 28 km. The Tutova river basin is situated in hill region. Cuibul Vulturilor reservoir is situated close to the confluence with Barlad river, and there are 5 gauging stations proposed for automatization. Along the course of Tutova river and its tributary Lipova, 33 inhabited areas have been identified.(Table 1)

Tabel 1 River Basin Tutova

No.	River with gauging station	Gauging Station	Locality	Advertising localities
1	Lipova		Malosu	
2	Lipova		Vl. Marului	
3	Lipova		Vl Caselor	
4	Lipova	Lipova	Lipova	
5	Lipova		Vl. Bugii	
6	Lipova		Satu Nou	
7	Lipova		Stejaru	Stejaru
8	Lipova		Doagele	Doagele
9	Lipova		Poiana Pietrei	Poiana Pietrei
10	Lipova		Dragomiresti	Dragomiresti
11	Tutova		Fundu Tutovei	
12	Tutova	Plopana	Plopana	
13	Tutova		Domeni	
14	Tutova		Rusenii de Sus	Rusenii de Sus
15	Tutova		Rusenii Razesi	Rusenii Razesi
16	Tutova		Straminoas	Straminoas
17	Tutova		Vladia	Vladia
18	Tutova		Babuta	
19	Tutova		Semenea	
20	Tutova	Radeni	Radeni	
21	Tutova		Fantanele	Fantanele
22	Tutova	Puiesti	Puiesti	
23	Tutova		Iezer	
24	Tutova		Iana	Iana
25	Tutova		Vadurile	Vadurile
26	Tutova		Bogesti	Bogesti
27	Tutova		Pogana	Pogana
28	Tutova		Crangu Nou	Crangu Nou
29	Tutova	Ciocani	Ciocani	
30	Tutova		Ivesti	Ivesti
31	Tutova		Pogdanesti	Pogdanesti
32	Tutova		Polocina	Polocina
33	Tutova		Coroiu	Coroiu

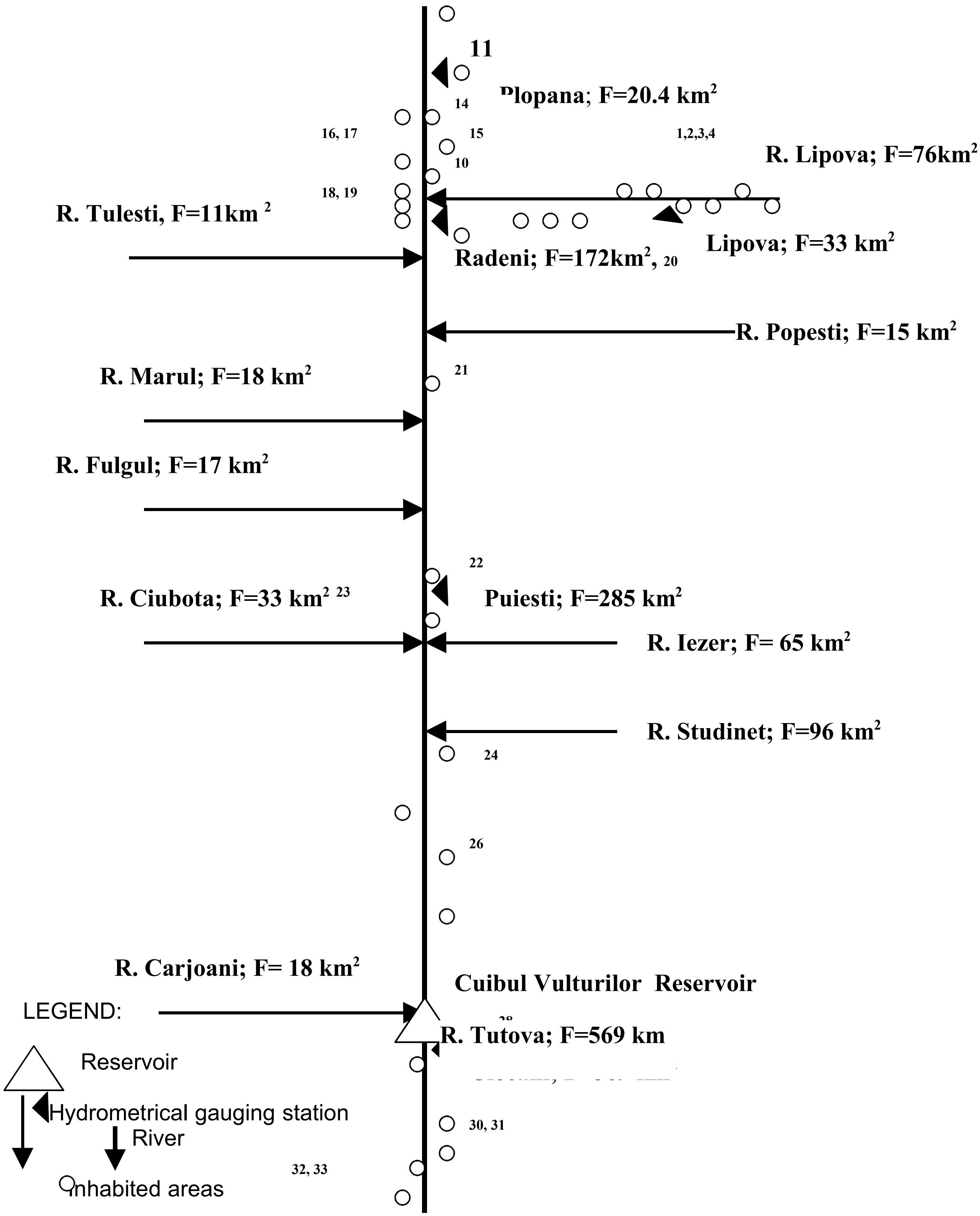

Fig. 1 Warning scheme in the Tutova Basin

Tutova river, a km ^{2} and 86 km in length. It has 9 tributaries of 1st degree with areas between 11 and 96 km^2 and lengths between 5 and 28 km. The Tutova river basin is situated in hill region. Cuibul Vulturilor reservoir is situated close to the confluence with Barlad river, and there are 5 gauging stations proposed for automatization. Along the course of Tutova river and its tributary Lipova, 33 inhabited areas have been identified.

To more easily express the social efficiency method, in this application it was considered that $E_s=N_l$. By applying the upstream/downstream limits establishment criteria, it has resulted that 19 of 33 inhabited areas can be warned. The number of inhabited areas that a gauging station can warn varies between 2 (Radeni gauging station) and 5 (Puiesti gauging station). Taking into account the above mentioned criteria, technically are considered as efficient those gauging stations which can warn more than 4 – 5 inhabited areas.

Ciocani gauging station, being situated immediately downstream from the “Cuibul Vulturilor” reservoir, has a smaller importance for warning, because downstream from it the flow is controlled, and based on the exploitation rules of the reservoir it is unlikely that floods should occur downstream.

4.Conclusions

1. In the conditions of market economy it is necessary to justify all expenses based on social and economical efficiency. So far these criteria where never applied in Romania for designing the national; hydrometrical network.
2. The present paper is a beginning in the quantification of the economical and social efficiency and it is necessary to develop it in the respect of the above mentioned criteria.

5. References

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