



# Sustainable Strategies of Urban Flood Risk Management with non-structural Measures to cope with the Residual Risk

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## The project **SUFRI**

improvement of flood risk management with non-structural measures

implement sustainable flood risk management, for

**advanced warning systems**

**vulnerability analysis**

**risk communication**

To achieve this goal six project partners from four European countries

Austria, Germany, Italy and Spain

worked within the ERA-Net CRUE initiative for the period of 2009 - 2011

recommendations for good practice of risk based management in flood-prone urban areas in consideration of the national differences

analyse national procedures, efforts of rehabilitation, public risk perception,

case studies of vulnerable European cities where flood events occurred in the recent past have been undertaken

## OBJECTIVES of SUFRI

Flood warning and floods in urban areas, especially for small catchment areas, are still research topic

Many recent research projects have focused on these topics like URBAS 2008, EWASE 2008, UrbanFlood 2010. Experiences of practical applications are still scarce

The project intention is provide an overview about flood characteristics in urban areas to improve flood management, and about general components and benefits of early warning systems

Different approaches have been used to reach this goal

- experiences with analogue warning systems

- weather data

- rainfall and flood forecast models

- flood maps and flood management plans

all themes related with warning systems lead to recommendations for practitioners and authorities

Regarding the basis principles of ERA-Net CRUE

resilience and community

the aspect of public participation gains in importance

participation of the public is seen as an important prerequisite design an effective risk communication for a crisis management

Therefore, the project SUFRI fills in two research gaps

provides empirical data on the subjective view of the citizens regarding natural hazards particularly regarding flooding, as well as the desired communication and information in the case of a flood occurring

an international comparison between the chosen investigation areas takes place

The project objective was divided into four main themes:

- Warning systems
- Risk assessment
- Risk communication
- Crisis management

key findings of the project

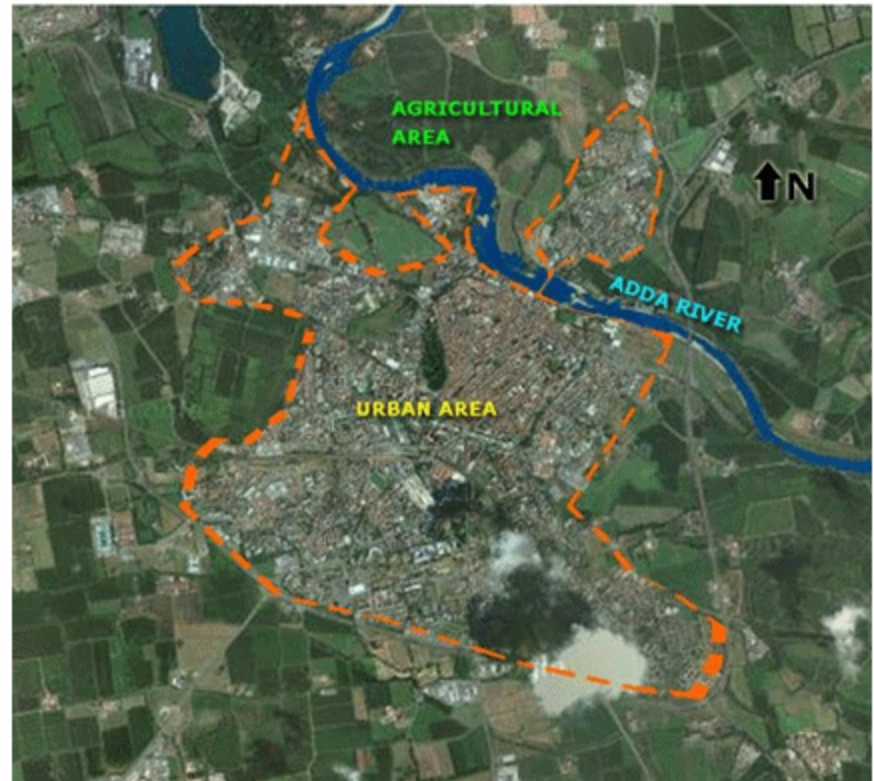
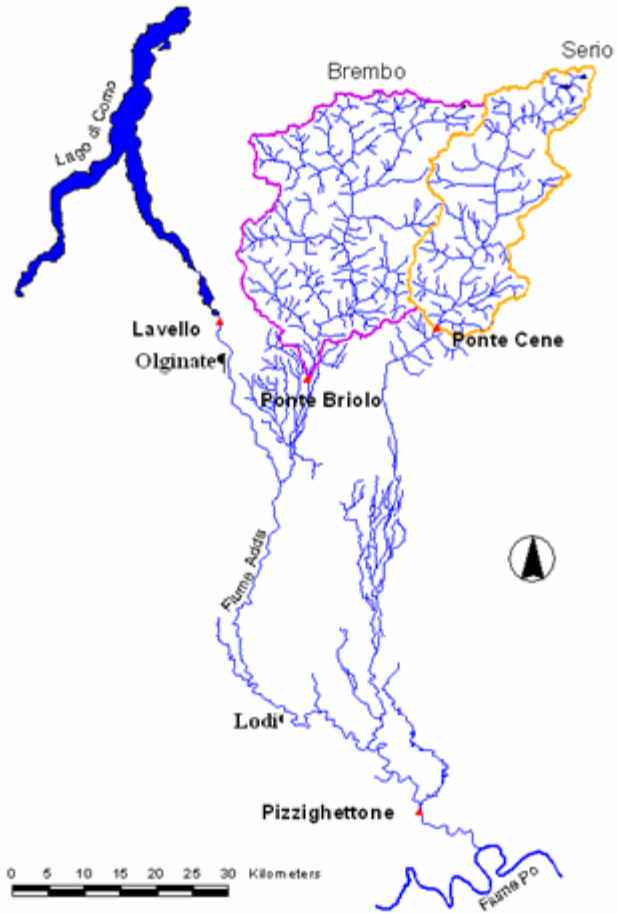
- Compilation of advanced warning systems
- Compilation of risk communication strategies
- SUFRI Methodology for pluvial and river flooding risk assessment in urban areas
- SUFRI Method for risk awareness of the population
- SUFRI Approach for crisis management planning
- Examples of use in  
Austria, Germany, Italy and Spain and their trans-national comparison
- International symposium UFRIM for communicating the research results



SUFRI project involves five case studies

- *Graz,*
- *Dresden,*
- *Lodi*
- *Benaguasil*
- *Arenys de Mar / Munt.*

## LODI TEST CASE



## A 1D and 2D study of flood prone areas in Lodi was performed by the University of Pavia

For the 1D model the river course is 130 km long

Inside the river channel 35 obstructions - [bridges](#), [barrages](#), [etc.](#) - can strongly influence the river flow particularly upstream for quite a long distance

The mathematical model used is based on shallow water equations written in a conservative form.

The mathematical model is numerically integrated with finite volumes techniques with two different numerical schemes

To estimate the roughness coefficient a method that refers to the formulation proposed by U.S. Geological Survey that correlate the roughness coefficient (using Manning) with the dimension of the grains in the river bed and the vegetation in the riverbed was used



For the 2D model the geometric description of the urban areas is represented by a Digital Terrain Model (DTM) 5 m x 5m

inundated areas, the velocity field, the water levels were computed



Inundated areas in Lodi town for 20 year return period



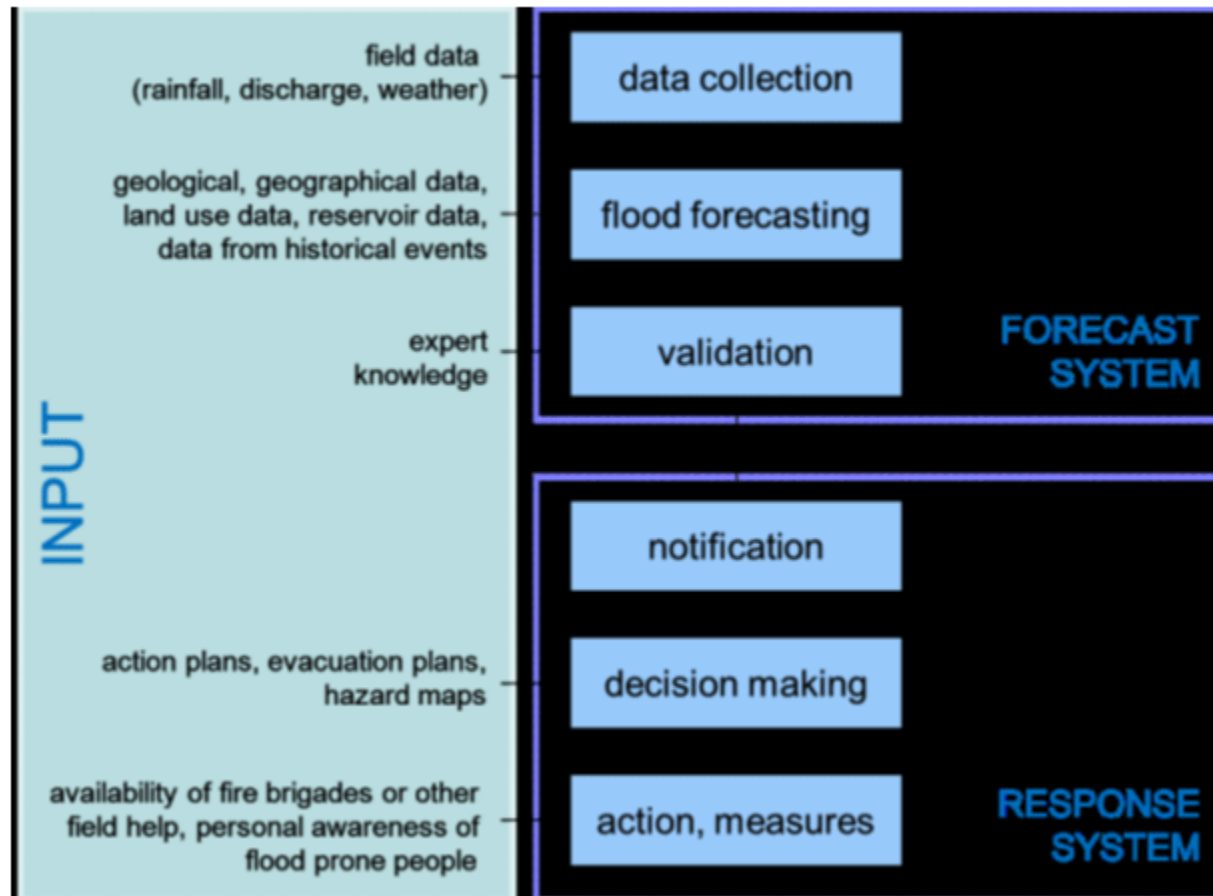
Inundated areas in Lodi town for 200 year return period



## WP2: Advanced Warning Systems of Small Urban Catchment Areas

### Specific Outcomes

- Compilation of advanced warning systems of small urban areas
- Experiences in different European countries



## Lessons Learned

- Flood warning system is the non-structural measure with best cost-benefit-ratio
- Rainfall-runoff-models for small catchment areas are still a topic of scientific projects
- It is beneficial to analyze automatic warning systems in case of other accidents and disasters too to get additional information and input
- Recommendation of installation of additional rainfall and river gauges at smaller rivers to get better data
- Sirens, diaphones or loudspeakers are cost efficient methods to disseminate warning messages to a local limited set of affected people even if they have no access to public media
- Flood warning messages should be clear, simple, understandable and without subjunctives
- Additional information should be provided by community helpline, TV, radio and the World Wide Web
- Centralised institutions can provide the needed expert knowledge and should be responsible for centralized data collection
- The response system should be centralized too, but on a lower administration level
- Hazard, risk or inundation maps are important for exact action planning in case of flood
- The review of warning systems was often only triggered by extreme flood events
- Early warning systems today can benefit more by establishing short communication

## WP3-Residual Risk and Vulnerability Analysis

### Specific Outcomes

- Tool to support flood risk evaluation in urban areas, applicable to inform authorities, local entities and stakeholders on decision-making for establishment of strategies for risk reduction
- F-N and F-D curves to represent risk results (societal and economic flood risk), useful for defining tolerability criteria for flood risk
- Evaluation method of the effects of several flood protection measures
- Applicable for different levels of information: from basic evaluations on flood risk to highly detailed estimations
- Case study examples

### Lessons Learned

- Risk evaluations from low level of information require assumptions → more conservative because uncertainty in results is high (particularly in the number of people exposed to a flood and hydraulic characteristics)
  - In case examples, economic risk has more significance than societal risk
- However, there is no doubt that public education and warning systems have an effect on risk reduction

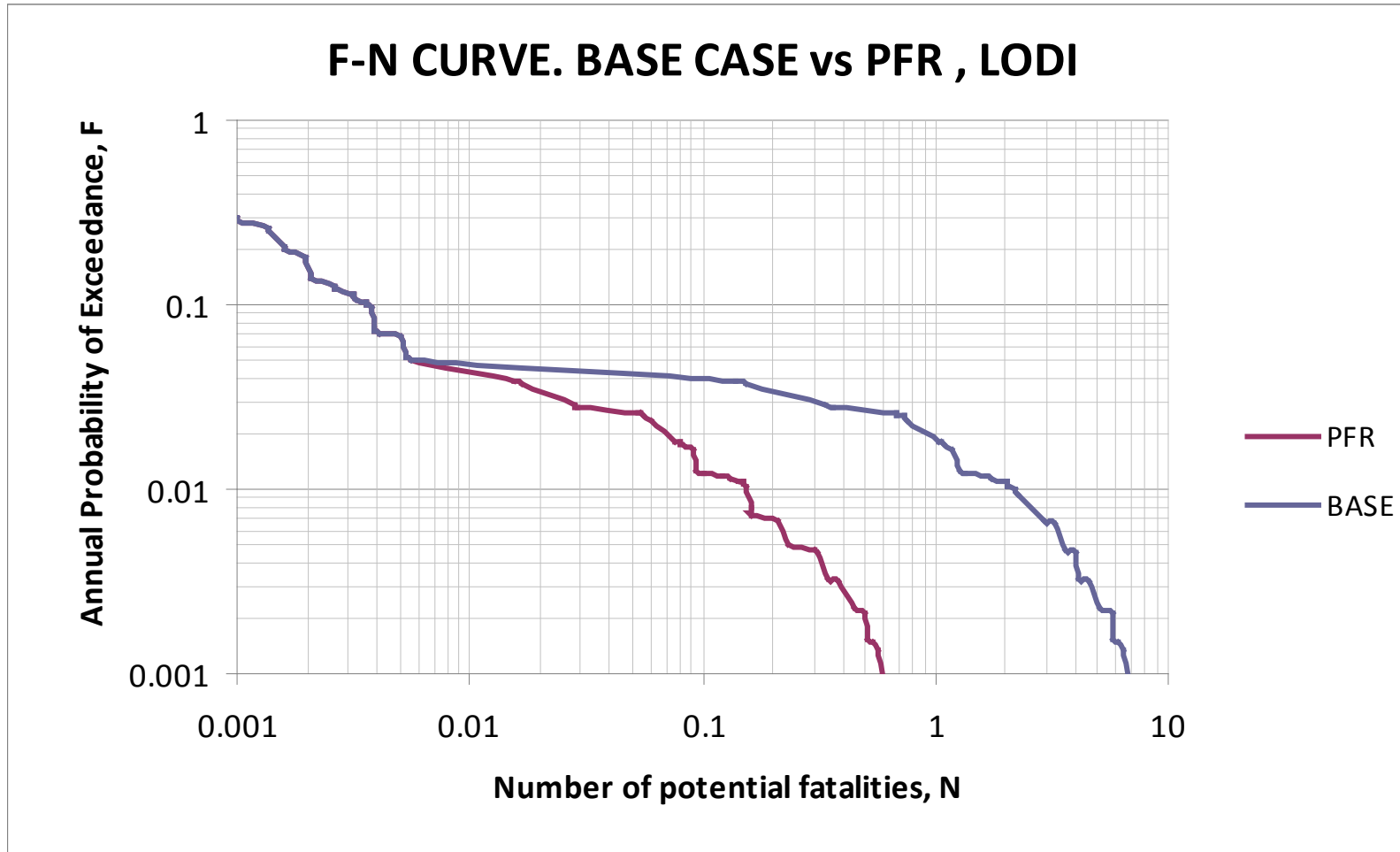
SUFRI methodology is based on the identification of all the important factors that influence risk quantification: sources of flood risk (river, heavy rainfall, defense failure, inefficient drainage system, etc.), vulnerability of the study area, etc.

The TU of Valencia has developed IPRESAS software and a dedicated methodology that provides a scheme that can be applied for different levels of information: from basic evaluations on flood risk to highly detailed estimations

The use of F-N curves enables the comparison of the current situation of the urban area with other situations from the consideration of non-structural measures.

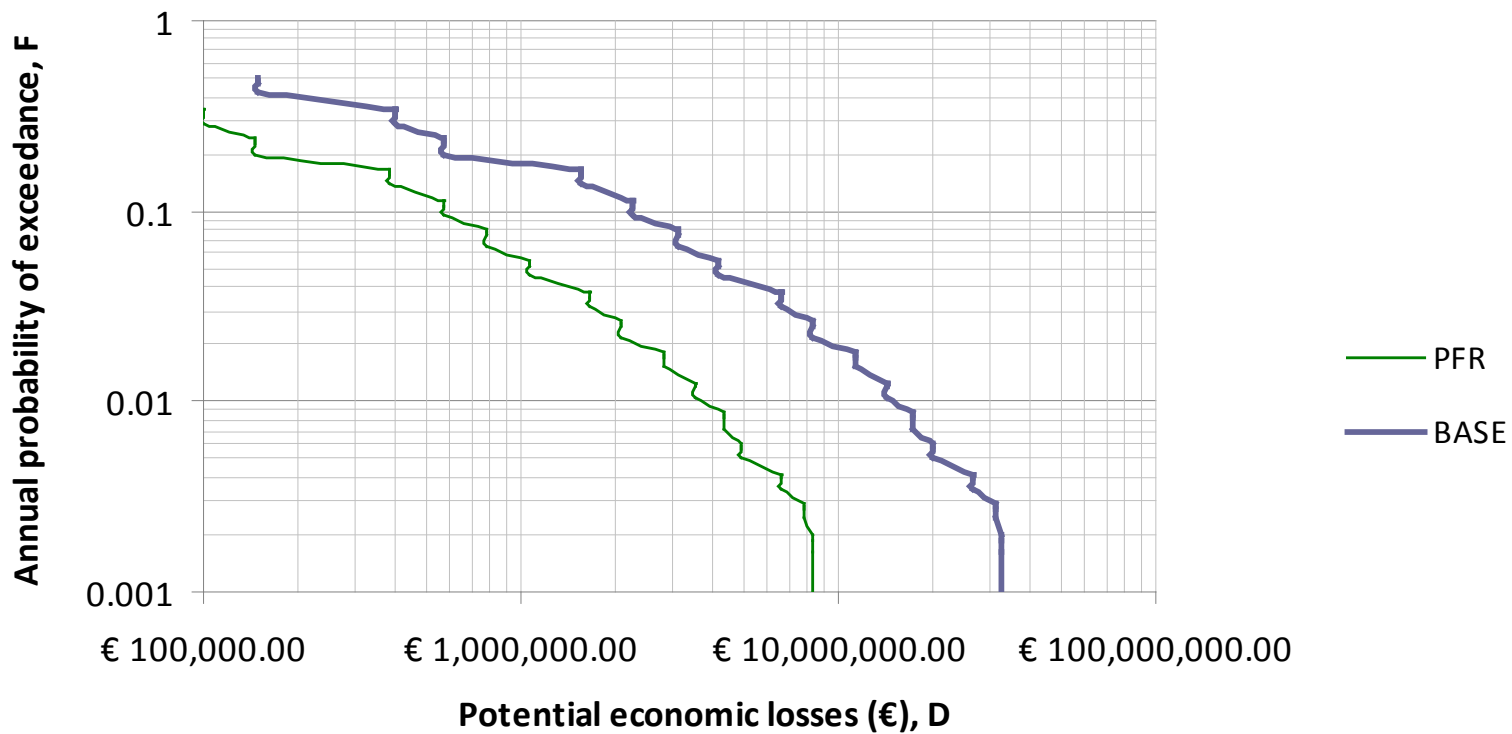
Uncertainty on the results will depend on available data and the level of detail of hydrologic and hydraulic models or calculations

### WP3: RISK ASSESSMENT





## F -D CURVE BASE CASE VS PFR, LODI



## WP4: Risk Communication

### Specific Outcomes

- Questionnaire in 4 languages (English, German, Italian, Spanish) to achieve data of the subjective view of the citizens about natural threats (especially flood), the desired communication and information in case of a flood event
- Guidance for hypothesis and connectivity testing regarding predefined questions (factor / cluster analysis)
- Guidance for successful risk communication
- Experiences in European cities (all case studies): public opinion poll
- Experiences in European cities (Graz, Benaguasil): information campaigns

### Lessons Learned

- The population feels a lack of information during a flood event
- Stakeholder, action forces and population need to be involved in the developing process of crisis management
- The willingness for cooperation is higher if people have the feeling of taken seriously.

Survey area	Residents in the area of the 100 year flood	Households in the area of the 100 year flood	Random sampling households to interview
Arenys de Mar / Munt	2282	570	every 2nd household
Benaguasil	800	200	every household
Dresden	4700	1175	every 4th household
Graz / Andritz	-	1321	every 4th household
Lodi	3000	750	every 3rd household

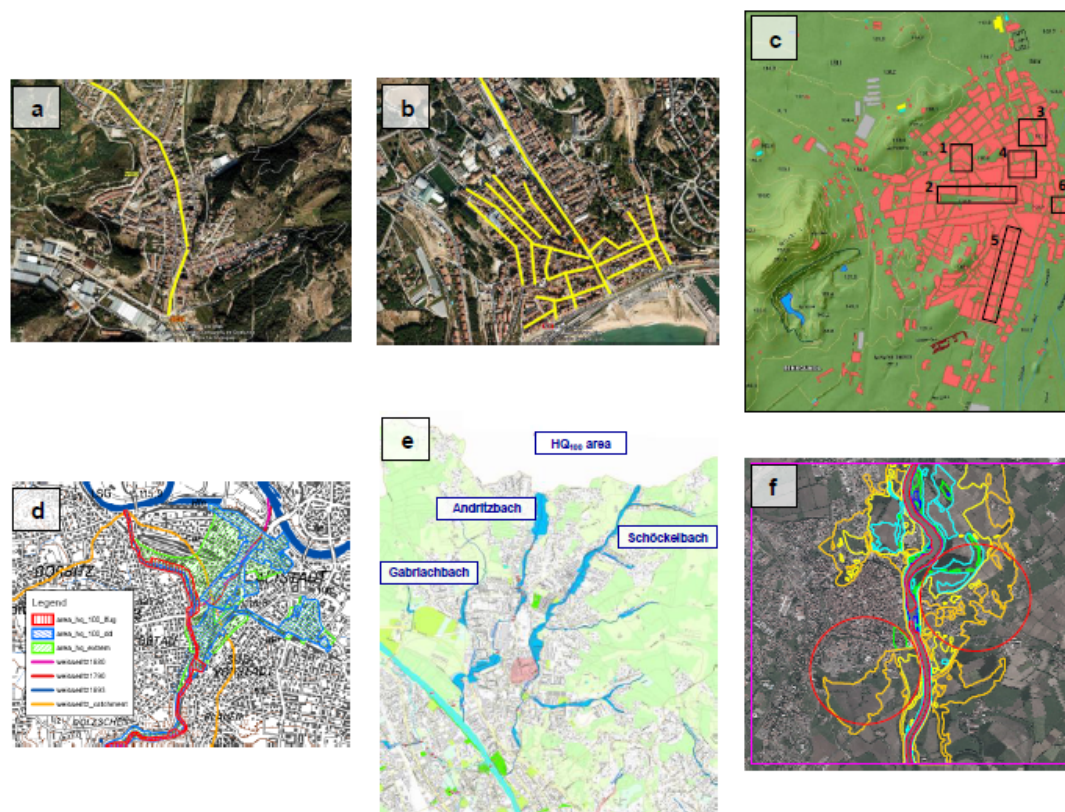


Figure 59: Investigation areas, a-b: Arenys de Mar / Munt, c: Benaguasil, d: Dresden, e: Graz, f: Lodi

Table 26: Return rate

Survey area	Households to interview <sup>78</sup>	Interviewed households <sup>79</sup>	Filled out questionnaires	Return rate
Arenys de Mar / Munt	285	3026 <sup>80</sup>	122	4%
Benaguasil	201	104	33	32%
Dresden	294	666	238	36%
Graz / Andritz	330	286	72	25%
Lodi	250	296	188	64%

The return rates range between 25 and 64 per cent and are thus to be recorded as exceptional in each survey area from a social scientific perspective. Only the return rate in Arenys de Mar / Munt is with 4% quite low

During the realization of the opinion poll different experiences have been gained

1. It's absolute necessary to adapt the modality of the investigation to the local circumstances in the case study area. Depending on the attitude and atmosphere regarding the authorities sometimes it could be useful to have them as partner, sometimes not
2. It is advantageous if the interviewer speaks the same dialect/language as the interviewed persons (e.g. Catalan in Spain).

RICERCATORI AL LAVORO NEI QUARTIERI DELLA CITTÀ COLPITI DALLA FURIA DELL'ADDA

# Paure e timori dopo l'alluvione: indagine dell'università di Pavia

■ Un'indagine internazionale sull'alluvione lodigiana del 2002. E il progetto che coinvolgerà il capoluogo nei prossimi giorni. Verranno distribuiti 250 questionari ai residenti delle zone colpite dall'esondazione dell'Adda. L'obiettivo è quello di misurare la percezione del rischio e le conseguenze psicologiche dopo l'ondata di piena di otto anni fa. Si tratta di una ricerca denominata Sufrì (Strategies of urban flood risk management), sulla gestione del rischio di inondazione in aree urbane attraversate da grandi fiumi, nel contesto del programma europeo Era-Net Crue.

Coordinata dall'università di Graz (Austria), l'iniziativa coinvolge alcuni importanti atenei europei (Cordoba, Valencia e Barcellona) e in Italia vedrà la partecipazione dell'università di Pavia, che realizzerà a casa un questionario in forma scritta. I residenti dell'area riverasca avranno a disposizione un questionario in forma scritta, proposto ad un campione di 250 persone. «L'indagine realizzata a Lodi - spiega il professor Luigi Di Natale, del dipartimento di ingegneria idraulica e ambientale dell'università di Pavia - è stata quella che ha avuto il maggior riscontro in tutta Europa, sia per numero di risposte, che per l'estrema rapidità con cui si è svolta. Ringraziamo quindi tutte le persone che hanno aderito, nonché l'amministrazione comunale di Lodi per la collaborazione e i volontari del nucleo di Protezione civile che



Pompi

10.11.2010

il Cittadino  
Quotidiano del Lavoro

IN CITTÀ IL MAGGIOR NUMERO DI ADESIONI NEL PANORAMA DELLA RICERCA EUROPEA

## L'alluvione a Lodi fa ancora paura: record nelle risposte ai questionari

■ Arrivano i primi risultati dell'indagine sul rischio esondazione a Lodi. Sono stati oltre 190 i questionari raccolti sui timori di alluvione del fiume Adda. Tanti residenti hanno infatti deciso di partecipare all'iniziativa promossa dall'università di Pavia, nell'ambito di un progetto di ricerca europeo, coordinato dall'università di Graz (Austria), con la partecipazione di alcuni importanti atenei internazionali (come Dresda, Valencia e Barcellona) e in collaborazione con il comune.

Lo scopo dell'indagine è quello di rilevare dati e sviluppare strategie di controllo delle inondazioni urbane. Un modello di studio per registrare la percezione del rischio tra la popolazione e le conseguenze psicologiche di eventi come quello della grande piena in città nel novembre del 2002. I residenti dell'area riverasca del fiume sono stati coinvolti attraverso la consegna a domicilio di un questionario in forma scritta, proposto ad un campione di 250 persone. «L'indagine realizzata a Lodi - spiega il professor Luigi Di Natale, del dipartimento di ingegneria idraulica e ambientale dell'università di Pavia - è stata quella che ha avuto il maggior riscontro in tutta Europa, sia per numero di risposte, che per l'estrema rapidità con cui si è svolta. Ringraziamo quindi tutte le persone che hanno aderito, nonché l'amministrazione comunale di Lodi per la collaborazione e i volontari del nucleo di Protezione civile che



Nella foto d'archivio le operazioni di socco

hanno supportato l'indagine. In corso la traduzione del fine di novembre verrà di Graz, che procederà confronto tra i risultati europei coinvolte. Ad estioniari sono stati i ric via, coadiuvati dai vol protezione civile di Lo comitato alluvionati, p

Data:

mercoledì 10.11.2010

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## IL GIORNO

Lodi - Pavia

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PROGETTO RICERCA EUROPEA DELL'UNIVERSITÀ DI PAVIA CHE METTE SOTTO LENTE I RESIDENTI DELLE ZONE AFFACCIAE SUL FIUME ADDA  
**Indagine sul rischio alluvione, 190 risposte a tempo di record**

— LODI —

SONO STATI oltre 190 i questionari dell'indagine sul rischio di inondazione compilati e riconsegnati dai residenti dei quartieri "affacciati" sull'Adda che hanno partecipato all'iniziativa promossa a Lodi dall'università di Pavia, nell'ambito di un progetto di ricerca europeo coordinato dall'università di Graz (Austria). «L'indagine — spiega Luigi Di Natale, del Dipartimento di Ingegneria Idraulica e ambientale dell'università di Pavia — è stata quella che ha avuto il maggior riscontro in Europa. Ora è in corso la tradu-

zione delle risposte scritte, che entro fine novembre verranno trasmesse all'università di Graz, che elaborerà e confronterà i risultati registrati nelle varie città europee coinvolte. Lo scopo del progetto è quello di rilevare dati e sviluppare strategie di controllo delle inondazioni urbane, oltre a registrare la percezione del rischio tra la popolazione e le conseguenze psicologiche di eventi come quello della grande piena che colpì Lodi nel novembre del 2002.

I RESIDENTI dell'area riverasca sono stati coinvolti attraverso la consegna a do-

IL SINDACO

«Così valuteremo lo stato d'animo dei cittadini dopo la messa in sicurezza

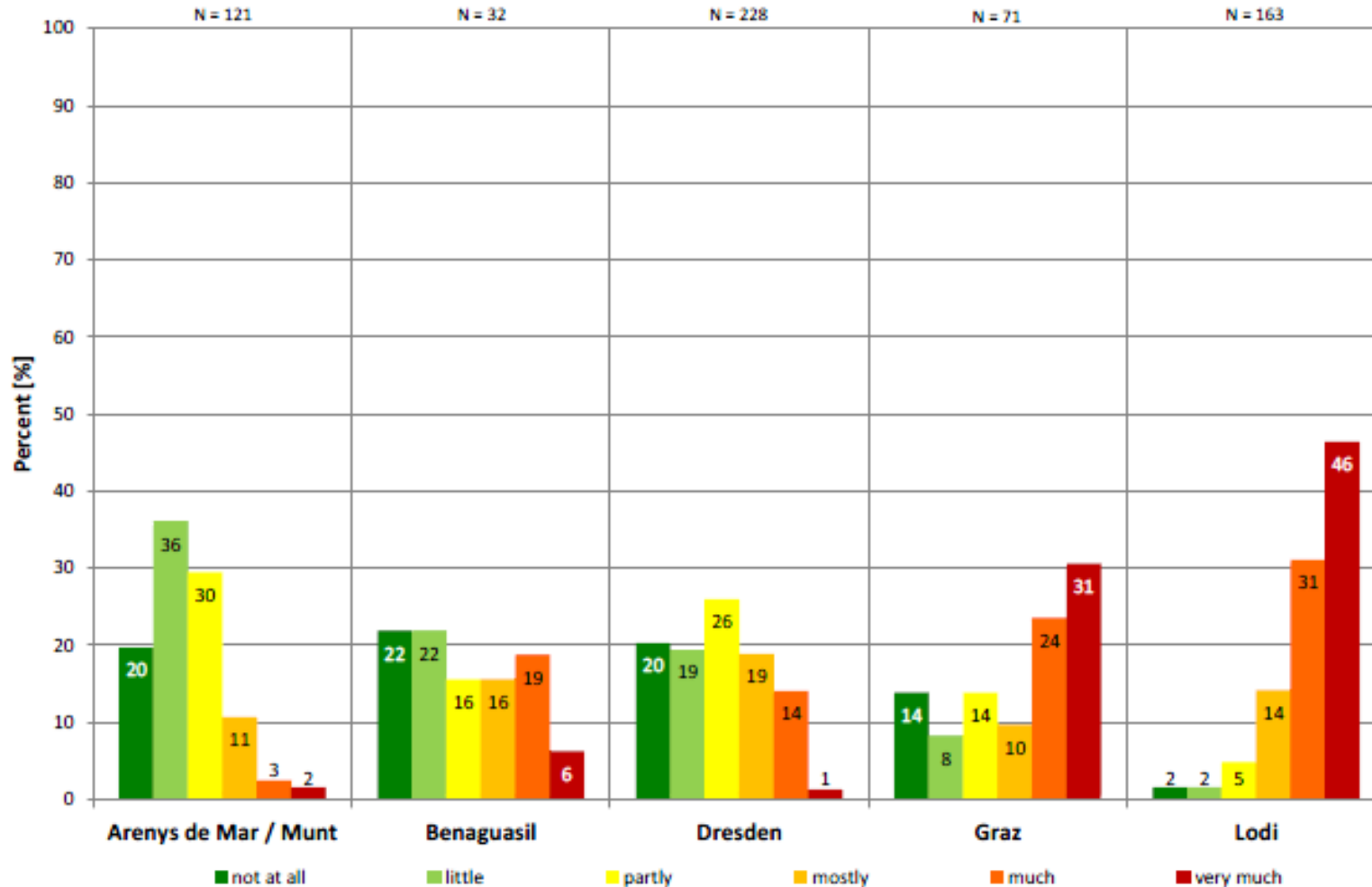
micilio di un questionario in forma scritta, proposto a un campione di 250 persone. A consegnare i documenti sono stati i ricercatori dell'università di Pavia, coadiuvati dai volontari del nucleo comunale di Protezione Civile di Lodi, con la collaborazione del Comitato Alluvionati presieduto da Carlo Bajoni. «La pronta disponibilità dei residenti — afferma il sindaco Lorenzo Guerini — ha favori-

to il buon esito dell'iniziativa, che andrà a vantaggio della sicurezza e della vivibilità dei quartieri vicini all'Adda. Crediamo che tutto ciò, unito alle impegnative opere di messa in sicurezza degli argini che il Comune sta completando e ai progetti di recupero urbano e turistico del fiume, costituisca un segnale atteso dall'intera città». Così l'amministrazione - assicura Guerini - potrà valutare, a distanza di 8 anni dalla grande piena del 2002 e dopo i lavori per mettere in sicurezza il tratto urbano del fiume, come si è modificata la percezione da parte della popolazione del rischio».



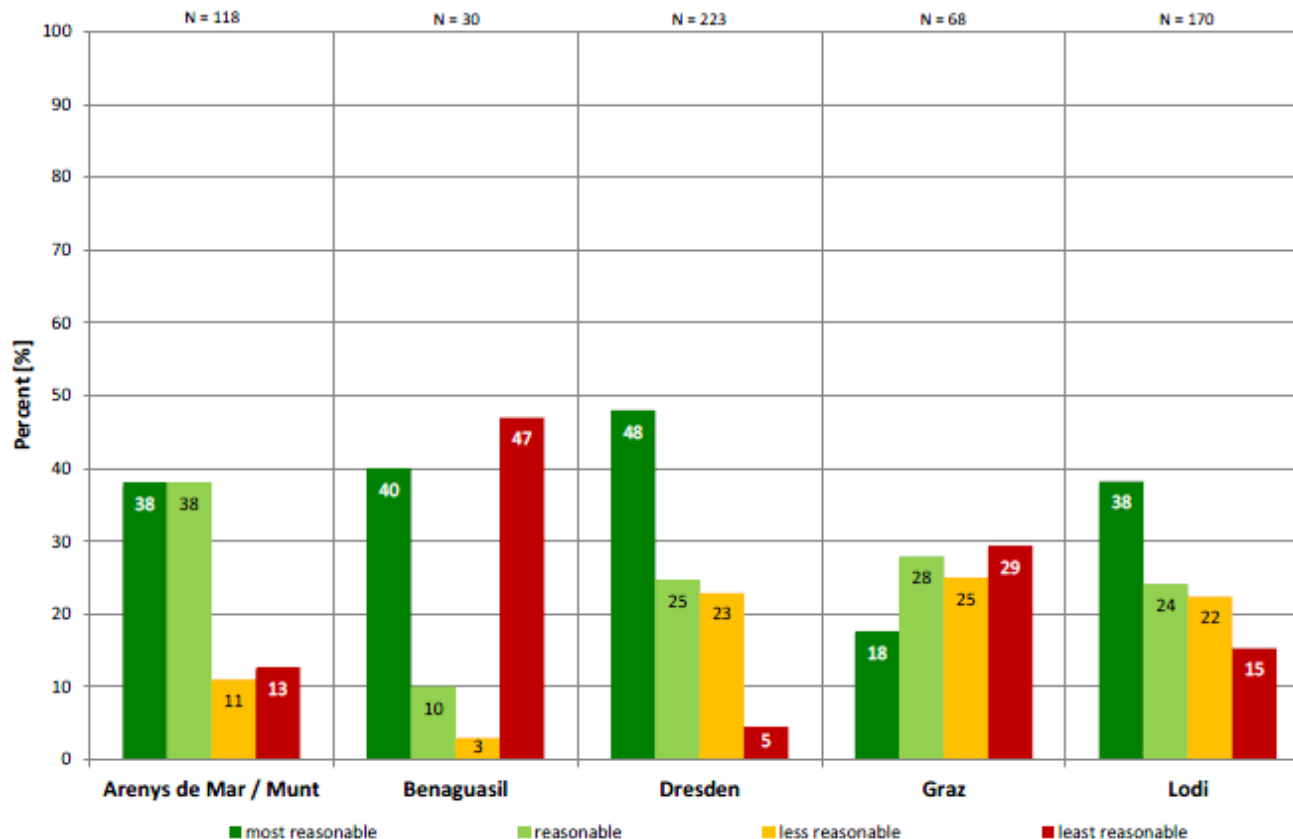
## Threat by floods

The results show, that the feeling of threat concerning floods is extraordinarily high in Lodi (46% feel threatened very much), followed by Graz (31%). Surprisingly only 5% of the people in Arenys de Mar / Munt feel threatened by floods. In Benaguasil and Dresden the quota of people who feel threatened and who not is relatively balanced. However the number of citizens who feel threatened very much is quite low (6% and 1%).



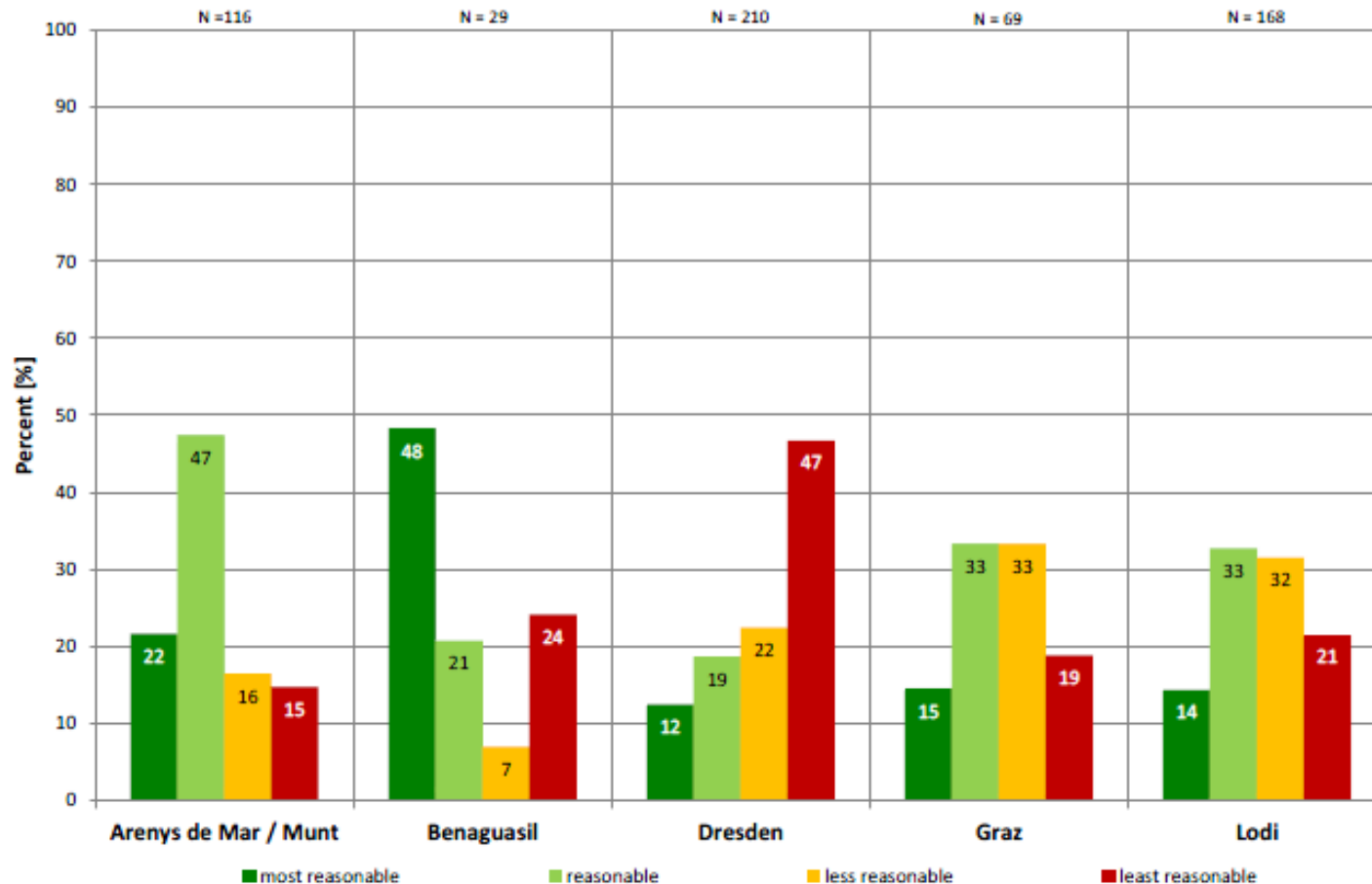
## Measures in order to reduce flood risk – early warning

In Arenys de Mar / Munt 76%, in Dresden 73% and in Lodi 62% are of the opinion that early warning is most reasonable or reasonable to reduce flood risk. In Graz 46% of the people think so, but here the number of those who are in the opinion it's reasonable is with 28% higher. In Benaguasil the same interesting tendency could be observed. 40% believe early warning is most reasonable but at the same time 47% that is least reasonable.



## Measures in order to reduce flood risk – self-protection

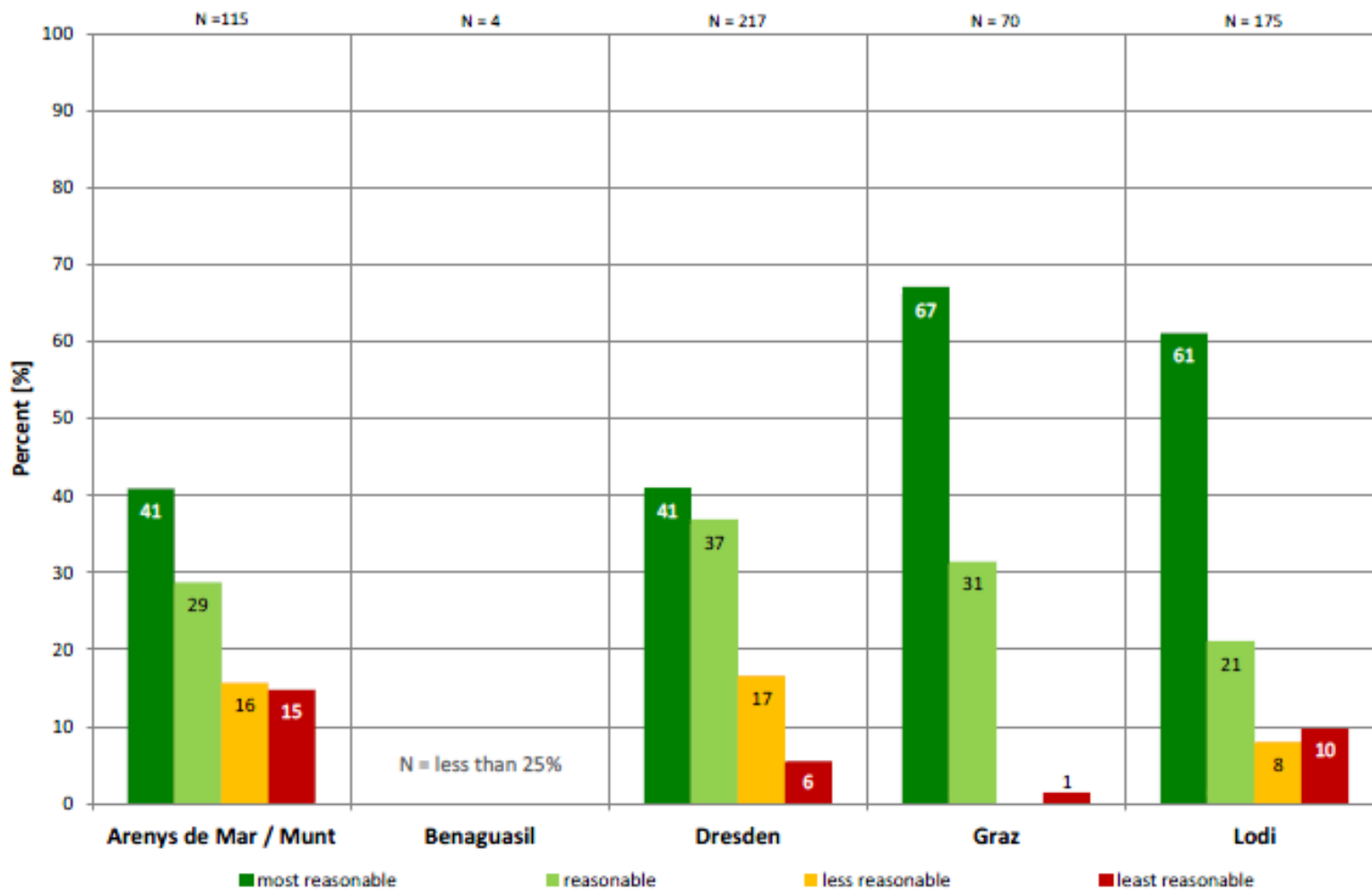
In the Spanish case studies self-protection is assigned more sensuousness, e.g. Benaguasil and Arenys de Mar / Munt / Munt 69% most reasonable or reasonable. In Benaguasil at the same 24% stated self-protection as least reasonable. In Dresden 47% of the interviewed people think that it's least reasonable. In Graz and Lodi the opinions are more in the middle field reasonable or less reasonable.





## Measures in order to reduce flood risk – protective structures

In all case studies the tendency is clear. Protective structures are considered as most reasonable or reasonably by the majority of the respondents.



## Evaluation of general statements

In the case studies the evaluation of the general statements listed below have shown the same clear tendency

- Man cannot control nature entirely: tendency applies
- One can protect oneself from floods completely: tendency does not apply
- There remains always a residual risk with natural hazards: tendency applies
- When I moved to this area I was aware of the flood risk: tendency does not apply
- I have coped psychologically with the previous flood events very well: tendency applies
- During heavy rain I remember previously flood events: tendency applies
- Because of the financial burden I can barely afford a holiday: tendency does not apply

The results show, that most of the people are aware of the fact that there is always a residual risk  
**Additionally it shows the importance of awareness training regarding the flood risk in the residential area**

### Affected by floods

in Arenys de Mar / Munt only 7% of the interviewed people have been affected by floods in the last 10 years

These percentage is much higher (> 60%) in the other case studies

### Frequency of affectedness

In Dresden and Lodi the majority of the people have been affected once in the last 10 years

In Graz and Benaguasil flood events have happened more often

## Health problems

The percentage of those who suffered from health problems after the last flood events is very low for Dresden and Graz.

In Benaguasil none of the respondents had any health problems

The highest percentage can be registered for Lodi

The most indicated types of health problems in all case studies are panic attacks/anxiety states, insomnia, irritability/anger and restlessness

## Preferred source of information in case of emergency

in all case studies, except Lodi, people like to be informed by the media

in all case studies, except Benaguasil, people like to be informed by emergency services.

the majority of the interviewed persons **don't like** to obtain information in case of emergency by **internet, on-site information centers, by friends / relatives**

## Information about flood issues on a regular basis

Regarding this topic the results show, that information by the media is preferred in all case studies

## Level of information during the last flood event

The results show clearly that the majority of the people felt informed very badly during the last flood event

The percentage is especially high in Lodi with 85%, followed by Benaguasil with 68%, Graz 53% and Dresden 52%

Due to a too low number of affected people an analysis was not possible for Arenys de Mar / Munt

### Assessment of available time span

The available time span was far too short for most of the interviewed persons:

Dresden 63%, Graz 56%, Lodi 82%

Due to a too low number of affected people an analysis was not possible for Arenys de Mar / Munt. And Benaguasil

### Knowledge about self-protection measures

The majority of the interviewed people in Benaguasil (73%) and Graz (67%) have indicated to know measures for self-protection

In Arenys de Mar / Munt 71%, in Dresden 67% and in Lodi 62% don't know about these measures

### Protective measures in the future

In all case studies, except in Benaguasil, the majority of the people will take protective measures in the future

### Assessment of solidarity efforts in the neighborhood

There is a clear tendency in all case studies, except Benaguasil, to assess the solidarity efforts in the neighborhood positive

In Benaguasil the opinions concerning this topic differ wider than in the other case studies, although 27% evaluated the solidarity efforts in the neighborhood as very good

## Case study Lodi

Despite the fact that the last flood event in Lodi happened in 2002, people in Lodi seem to have experienced this events very intensely.

In comparison to other case studies difference in the answers are conspicuous

### They

- feel most threatened by floods
- rated the flood risk for them personally, inhabitants of their house and of their neighbourhood
- highest rated their personal damage regarding material and financial casualties highest
- rated their personal damage regarding health problems highest
- rated the statement “I have coped psychologically with the previous flood events very well” with 46% rather applies and 32% applies. A clear difference to the other case studies, which answered with >60% with “applies” is noticeable
- stated to need the longest time to prepare sufficiently for a flood
- don't like to be informed by the media as single case study
- stated with the highest percentage (86%) to feel uncomfortable because of missing information
- show the highest percentage regarding a very bad level of information during the last flood event

**GRAZIE PER  
L'ATTENZIONE**