Fiche pédagogique **Collectif MAPS** maps	FLOOD-UP 	14/06/2018 MAPS 11 VERSION 0.1

Domaine d'application : géographie, etc...
Spécificité pédagogique :serious game
Niveau du public visé : Débutant, intermédiaire, confirmé

Life saver or just trying to cope during flash floods?

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INTRODUCTION AND RESEARCH PROBLEM

Flash floods are high-impact, occasionally catastrophic events that result from the intersection of hydro-meteorological extremes and society at small space-time scales, generally on the order of hours. Because flash flood events are generally very localized in space and time, they are difficult to forecast with precision and can subsequently leave people uninformed and subject to potential harm. The way that flash flood phenomenon propagates ad threats lives and property depends on many factors including the distribution of flood structures (e.g., dams, bridges), the critical infrastructure (e.g., schools, hospitals, electricity industry), and human population.

Emergency managers are challenged to combine all the possible (sometimes uncertain) information and resources available during the crisis to take relevant decisions towards protecting their area of responsibility. Efficient emergency management relies not only on technical expertise but also on personal skills of the managers involved in decision-making. Therefore, training decision making in emergency situations is very important to improve the capabilities of decision-makers to respond to life-threating situations under time pressure and stressful conditions. Serious games are already recognized in the literature as useful tools for training since they offer an environment were trainees can experience demands of emergency management under stress before the real crisis strikes (Crichton et al. 2000).

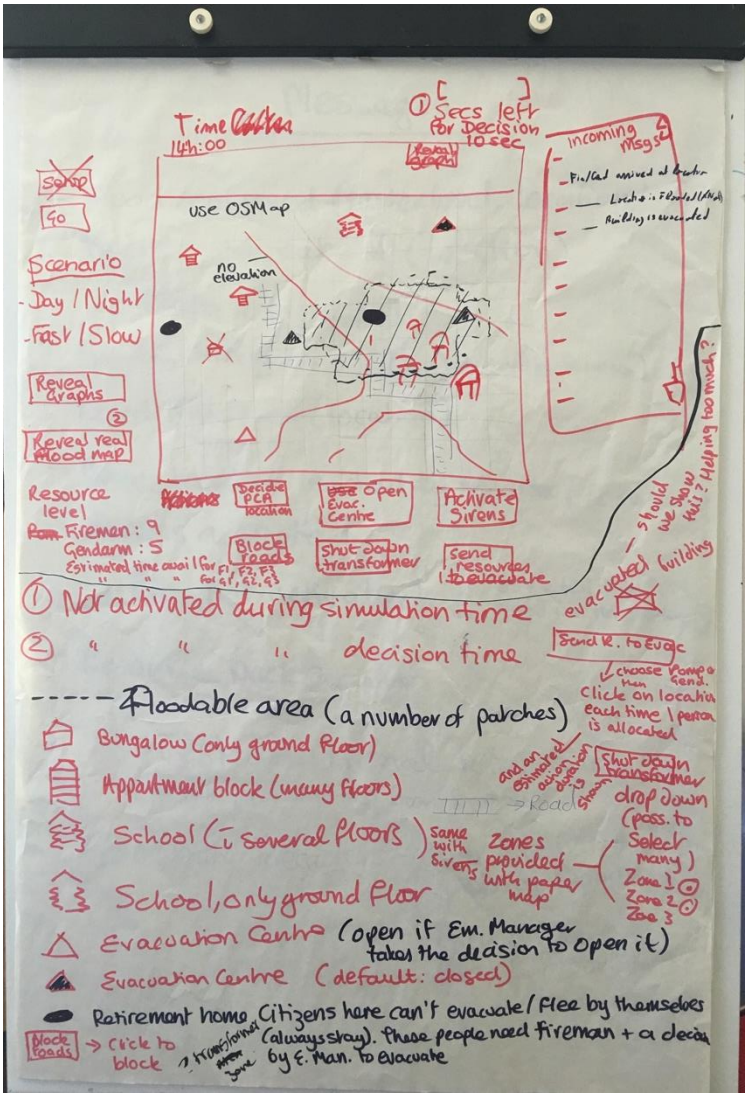
In this direction, we propose to develop a serious game that focuses on the emergency management of a city under the threat of flash flooding. The simulations seek to examine and ultimately « teach » to the player what are the elements that challenge efficient official emergency response during flash flood events and how the best management strategies can be achieved. The game aims to present realistic constrains to the players emerging from the:

- Uncertainties embedded in flash flood forecasts (e.g., localised short-fuse flash flood events can not be predicted based on given Flood Zoning)

- Limited time and resources to coordinate emergency response
- Complementary or contradictory information provided by official and/or unofficial sources

A - Définition du modèle

The aim of this serious game is to train an emergency manager to manage a flash flood crisis in terms of the effective use of limited resources, in order to save the maximum number of lives. Critical spots for intervention (e.g., residencies, schools) are distributed in the area under concern and shape a realistic environment for the trainee (see conceptualization in Fig.1). A flash flood scenario is developed for a small catchment (<20 km2) with the aim to:



- Generate educational/training cases of decision-making under pressure,
- Highlight the challenge of managing an overload of information arriving from different sources during the crisis,
- Explore the effect (positive or negative) of citizens' involvement in the crisis information provision.

The player acts on the behalf of

the Emergency Operation Center (i.e., the corresponding COD in France) and he/she is called to:

- ⇒ Protect in the best possible way the life of citizens, i.e., minimize the victims ,
- ⇒ Efficiently use the available human (e.g., fighrefighters, police officers) and material (e.G., sirens) resources in a short time,
- ⇒ Manage the electricity supply in the time of the crisis (e.g., potential power cuts because of flooding slow down or bother the emergency operation such as evacuations such as sirens alerting and evacuations).

Fig. 1 Illustration of the conceptual interface design.

We hypothesize that multiple progressive games will have a positive contribution in the:

- Increase of situational awareness and better realization of the advantages and drawbacks of the player's decisions for emergency activities.
- Development of a set of successful response patterns that enlarge the experience of the player (possibly an operational emergency manager) and may be used to design improved emergency strategies and protocols in the future.

B - Contextualisation du modèle

The model deals with emergency management operations in Biot city in France. Biot city is about 15 km^2 and includes about 9,000 inhabitabts. The player will be provided with an illustration of the study area that locates critical buildings and roads and provides information about the official flood zoning designed for the area (Fig. 2). Additional information will appear during the game in the format of "real-time" messages sent either by official sources (e.g., fire service) or the public (e.g., posts in twitter). This information has to be evaluated by the emergency manager in terms of validity and relevance and then get priorized for action if needed (e.g., ignore fake news and junk messages). The game session simulates 6 hours of a hypothetical flash flood event. The time runs continuously and decisions have to be taken every 30 minutes that correspond to 1'30 in the game. The emergency manager has a given timeslot to decide and apply his/her emergency actions (5 minutes that correspond to 15

seconds in the game). The interface is designed as a user-friendly environment in NetLogo where the player will be able to execute his decisions through simple buttons.

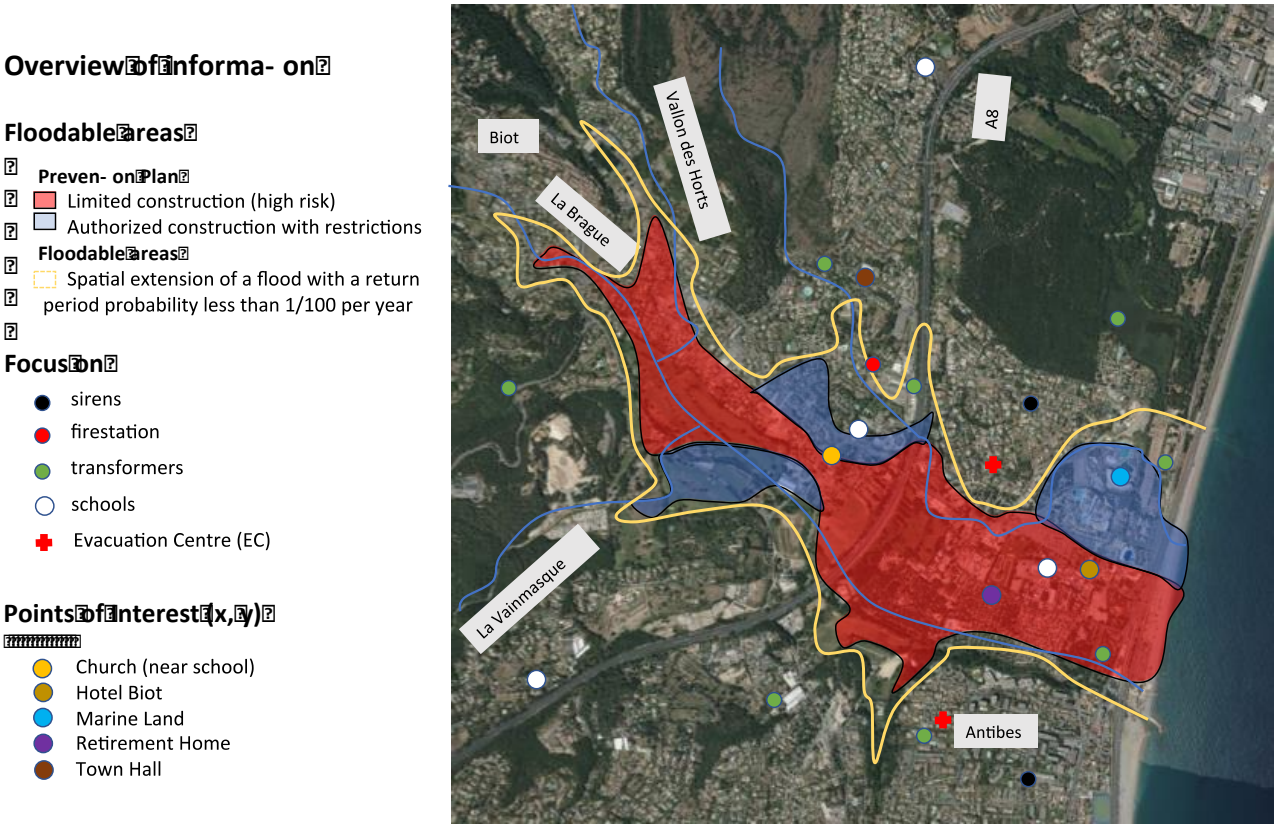


Fig. 2 Map of the Biot area with information on the flood zones (red and blue shaded areas) as well as critical points for intervention presented to the player.

The player will need to specify the location of a Coordination Centre, which is the site from which he/she will issue commands. If needed, an Evacuation Centre (EC) can be also opened to host evacuated citizens. As crisis manager, the player may decide to open a shelter and send resources (i.e., fire-fighters) to start the evacuation of a building (school, private building, retired home, hotel). Human resources (i.e., local police officers) can be also sent to close (block) roads to prevent road accidents (Fig.3). As human resources are allocated to different sites of emergency, the remaining resources available are reduced. Depending on the incident a certain amount of time is required for the fire-fighters to complete the evacuation operation and return to the Coordination Centre (CC). In general, the evacuation time may largely vary depending on the vulnerability of the population under concern (e.g., old people

with kinetic problems or special needs population such as hospitalized people or students who need special attention and services) (Quezada-Hofflinger et al. 2017). However, individual characteristics (e.g., age, gender) and perceptions (e.g., feelings of attachment, willingness to evacuate) are out of the scope of the current model and are not assigned to our agents. Therefore, it is not possible to assess social vulnerability and estimate the exact time needed for the hypothetical population located in the area. To account for potential variations in the evacuation time, though, a random duration from a range of values (between 30 and 150 minutes) is assigned every time that a fire-fighter reaches the target to evacuate. After this time, the fire-fighter is supposed to return to the CC and becomes again available to the crisis manager. To inform citizens for an imminent crisis situation, the manager should always activate sirens in the city. In case of severe flooding in the area of the power stations, the manager can prevent important costly damages by cutting the electricity service. Though, this action needs careful consideration because electricity is necessary for the operation of resources required for risk communication and response (e.g., activation of sirens).

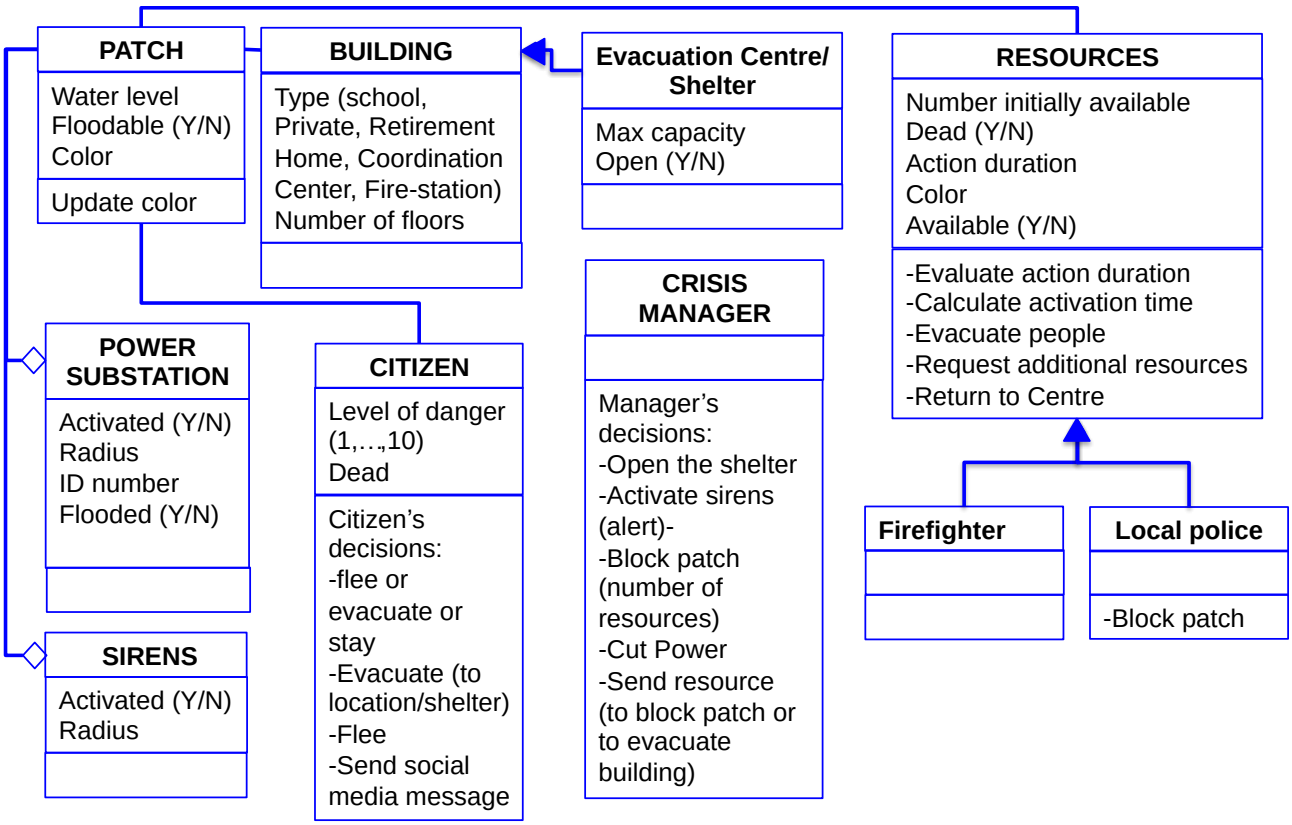


Fig. 3 Class diagram of the FLOOD-UP serious game for flash flood emergency manager.

C – Fonctionnement du modèle

Biot area is modeled as a set of patches that are grids of 50x50 meters. Every patch is attributed a flood level (0 for no flooding (F0), 1 for flash flooding (F1) and 2 for severe flash flooding (F2)), and it is characterized as floodable or non-floodable if it is located in the flood zone or not, respectively. Buildings and roads are situated within patches and people (initially distributed in the buildings of the area) start their activity from their original patch.

Activities for the citizens:

As shown in the class diagram in Fig.3, citizens of Biot City are attributed a probability of injury or death, or they are considered dead. We assume that citizens are aware of the flood either by observing the flood level in their patch or by listening the sirens activated by the emergency

manager. If there is no flash flood (level=0) or low level of flash flooding in their neighborhood (level=1), the citizens does not perceive a high danger and stays in his building keeping on his regular activity (Fig.4). As neighborhood we consider an area within a radius of about 100 m (2 patches). In case that the citizen observes a high flash flood level in his neighborhood (level=2) or the sirens inform him for an imminent severe risk then he starts seeking safety. We hypothesize that if the agent is in a two-store building or so (>1 floors) he will go upstairs to avoid flash flood waters. If there is no higher floor to shelter him he will try to seek safety outside his building and potentially move to the announced Evacuation Centre (EC) selected and activated by the player (see method "Evacuate yourself to EC" in Fig.5a). If the player does not activate a certain EC for a given amount of time after the start of the game, the citizen is considered uninformed about possible official shelters and he "flees" around seeking a non-flooded neighborhood (see method "Flee" in Fig.5b). Every time that the citizen meets a flooded road or a flooded patch after him he gets a probability of injury or death. The probability increases for higher flood level (i.e., Pr(injury/death)=5% for F1 and Pr(injury/death)=10% for F2). The maximum probabilities are stored and the maximum probability assigned to each citizen is presented to the player as an indication of the on-site situation during the game).

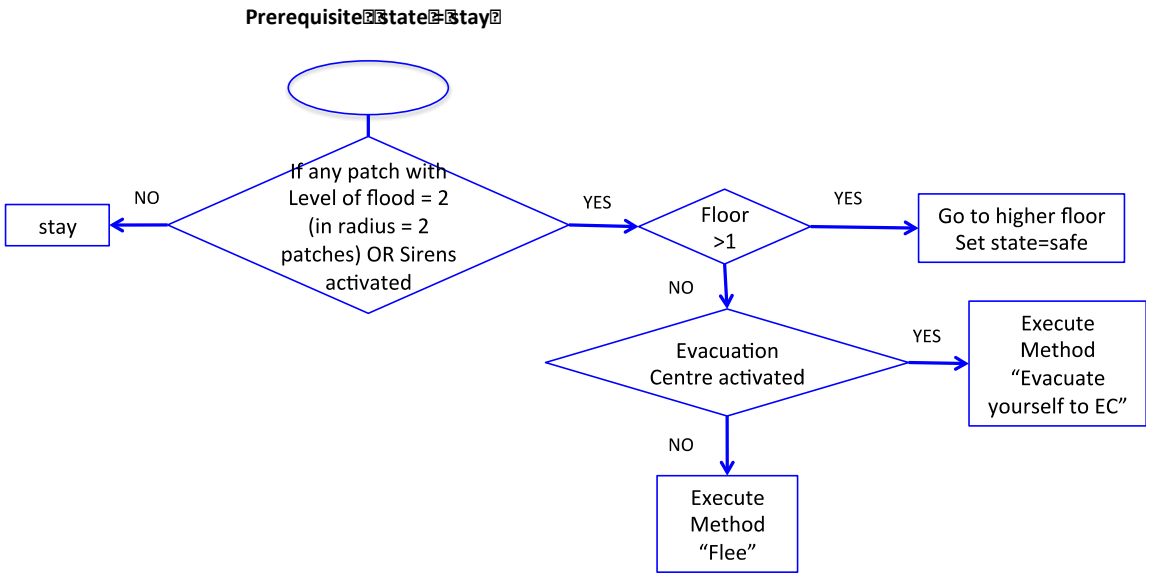


Fig. 4 Activity diagram for the agent "citizen".

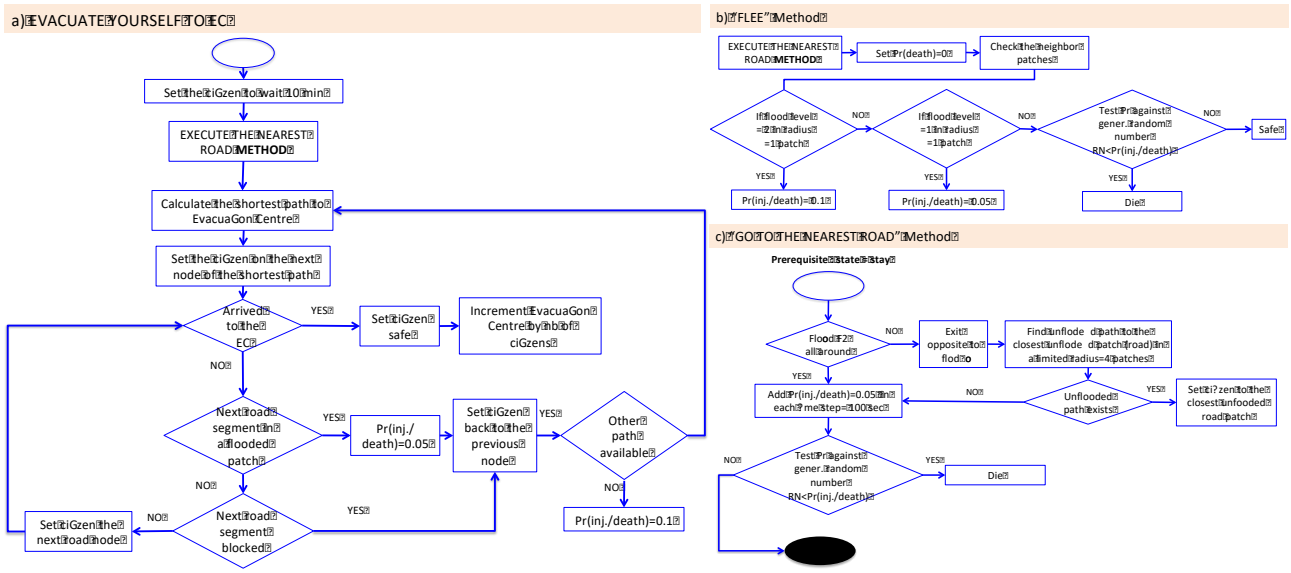


Fig. 5 Methods for citizen's decision a) to evacuate himself to the Evacuation Centre, and b) to flee seeking a safe neighborhood. Both methods execute the "Go to the nearest road" method (c) to activate the movement of the citizen towards a safe path.

Activities for the resources:

Once the emergency manager opens an EC and sends firefighters to evacuate citizens from specific locations in the city, the fire fighters are located to the selected patch and look for population to evacuate. As mentioned previously, a random duration between 30 and 150 minutes (values based on response time to flood events estimated by Quezada-Hofflinger et al. 2017) is selected to define the time required for the evacuation process to be completed and the citizens to be allocated to the EC. After the evacuation time the firefighters are assumed to be again available in the CC. The local police officers are only used in case of road blockage ordered by the emergency manager and it is hypothesized that once they are sent to the selected patch they stay on-site until the end of the event (i.e., end of the game).

EVACUATE BY OFFICIAL FIREFIGHERS

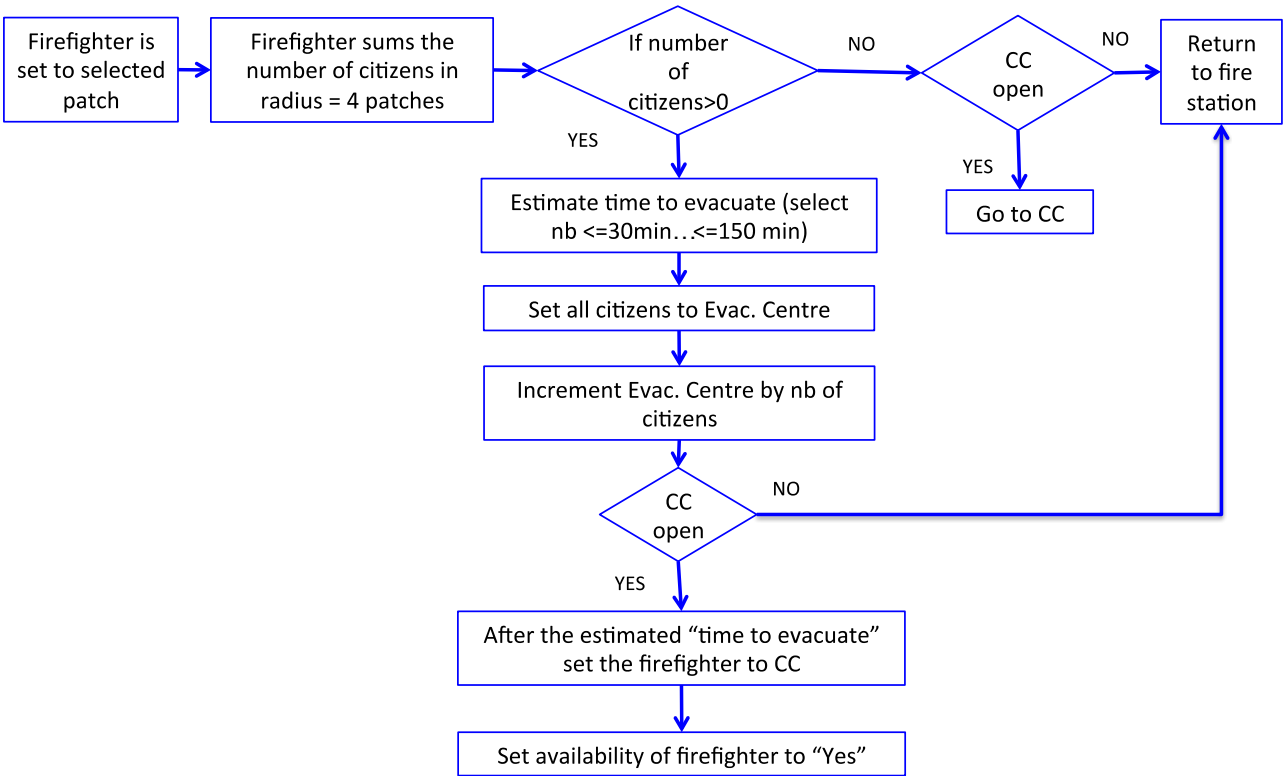
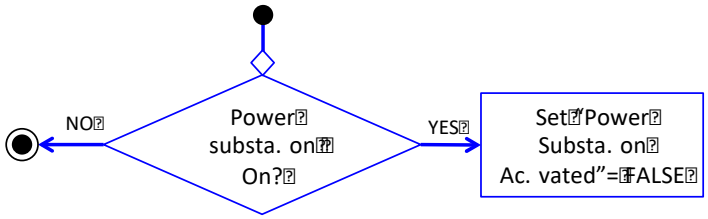


Fig. 6 Method for fire-fighters to execute evactuation operations.

Figure 7 shows the two simple methods that are applied in the case that the manager decides to cut power in a specific substation (Fig.7a) and its effect on the activation of sirens in the area operated by this specific substation (Fig. 7b).

a) Cut Power



b) Ac. vate Siren

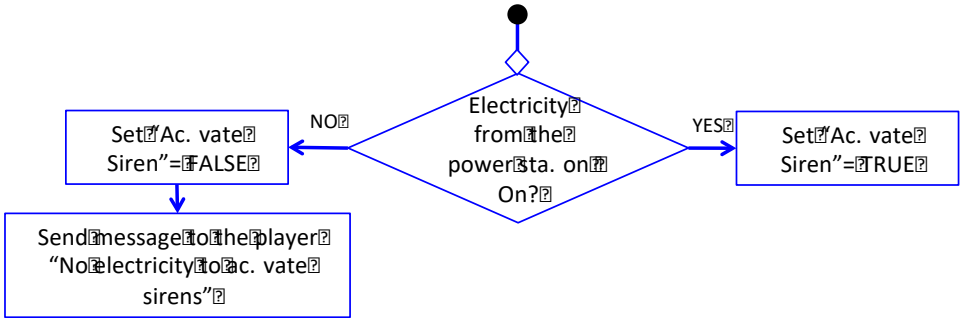


Fig. 7 Methods for a) electricity cuts in case of flash flooding in the area including the power substation, and b) sirens deactivation in case of lack of power due to flash flooding.

D - Exploration du modèle

1. Manipulation du modèle

Figure 8 shows the interface of the game designed in NetLogo Platform.

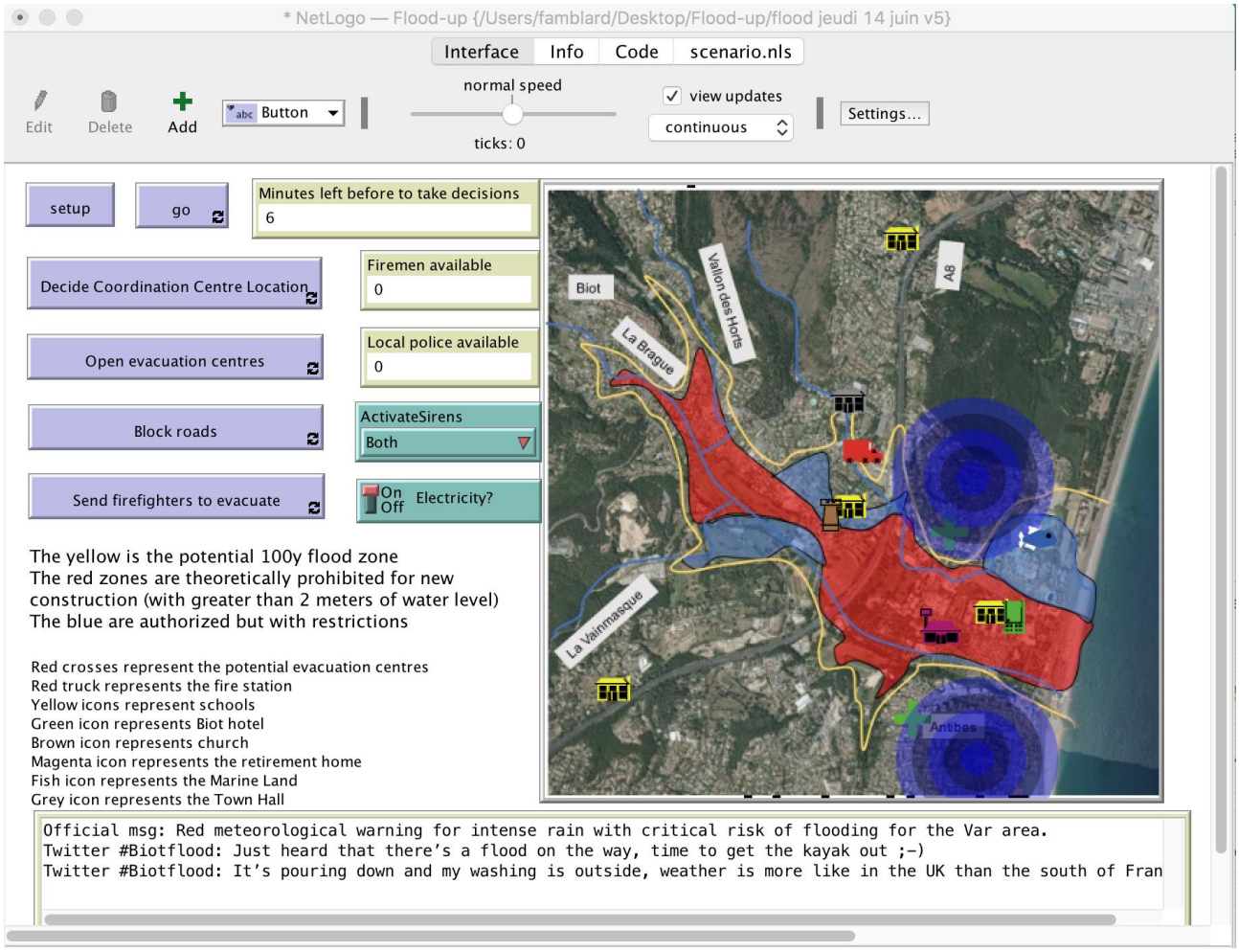


Fig. 8 Interface of the FLOOD-UP Game in NetLogo environment.

Input Data - Maps

The displayed map (Fig. 8) allows the player to visualise the emergency area. The area is focused on the downstream part of the Brague watershed, which was strongly affected by the Octobet 2015 floods (a depth of more than 2m of water in the valley floor was reached with record flows, especially on small coastal watersheds. 3 people died in a retirement home, there were also many damages, especially in the activity zone near the sea).

Three areas are shown:

- The flood zone (in yellow) defines the potential maximum area defined in the 100-year flood (a well known reference value)
- Regulatory zones from the Flood Risk Prevention Plan (PPRI), show the zones theoretically prohibited for new constructions (in red), with a water level greater than 2m in a 100-year flood. Authorized zones, with restrictions are shown in blue. These zones, which are specified in official documents, are used when the Coordination Centre is put into place to manage major flood crises (notably by the Referent Flood Department, RDI).

Several Communal Buildings (ERP in French)
- 1 church,
- The Town Hall,
- A hotel
- Marine Land

were placed on the map to see if the player takes into account these important public buildings in the crisis management strategy (there are particular references to these buildings in the information messages for the player).

Of the 4 schools, 1 is in a flood zone (the attention of the player subtly directed to this aspect). The location of the rescue centre and the 2 evacuation centres are also indicated, as well as the electricity substations. If the sirens are actiavted, 2 appear on the map. The sirens have a radius of 2km (this distance has been selected because it is inbetween the manufacturer's specification, which define the theoretical sound radius up to 3km, and reality, which show that from 1km, the sirens sound is no longer audible).
The points and zones have been defined from design software, due to the inavailabilty of GIS software. Nevertheless a link could be created with QGIS and downloading maps from OpenStreetMap. The maps of the flood zones are currently available on many platforms, such as CarMen, ORNM, GeoRisks, and the crisis management could be tested under other conditions, especially since the flash floods appear under very variable condition.

Information flow duting the game - Official & unofficial messages

Of particular note is the message window displayed on the lower part of the screen (Fig. 8). The message window acts as a trigger for the player to react to the evolving situation. The

messages are numerous, thus mimicking the real situation where the emergency manager is overloaded with information, some of which is contradictory, irrelevant, or false. The speed at which the messages appear is very quick, with a message appearing on average every few seconds. This was done in order to mimic the fact that the emergency manager needs to make important decisions under tight time constraints in stressful situations. The messages represent a specific scenario (shown below):

ID number	Message	Reason for the message and/or possible response from the player
1	Official msg: Red meteorological warning for intense rain with critical risk of flooding for the Var area.	*Warning to prepare player*
2	Twitter #Biotflood: Just heard that there's a flood on the way, time to get the kayak out ;-)	*Junk Tweet*
3	Twitter #Biotflood: It's pouring down and my washing is outside, weather is more like in the UK than the south of France!!!	*Junk Tweet*
4	Official msg from firestation: Increasing water level confirm for the La Brague river	*Player may send resources*
5	Twitter #Biotflood: Ha, ha big warning for floods, you must be joking, no problem to drive around in my 4 X 4	*Junk Tweet*
6	Official msg: 2 people injured in flash flood car incident near the Church and School	*Player should realise children need saving*
7	Official msg: 100 people have called the emergency call centre (18) to report flooded basements	*Stress the player*
8	Official msg from firestation: Define Cooridination centre and send help to victims as soon as possible	*Reminder to player*
9	Twitter #Biotflood: Anyone know if the schools are open?	*Player should attend to those vulnerable*
10	Twitter #Biotflood: Should I collect my son from school, I hear that it will be evacuated soon.	*Player should attend to those vulnerable*

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11	Official msg: Ground floor of Hotel Biot is flooded	*Player may send resources (mistake!)*
12	Twitter #Biotflood: I heard that the area around Hotel Biot is flooded, but there's nothing near me.	*Set of contradictory tweets*
13	Twitter #Biotflood: Any news of the flooding near Hotel Biot, I'm worried	*Set of contradictory tweets*
14	Twitter #Biotflood: Area around Hotel Biot really flooded	*Set of contradictory tweets*
15	Twitter #Biotflood: Exaggerations! Only a couple of centimetres of water around Hotel Biot	*Set of contradictory tweets*
16	Twitter #Biotflood: Advice: if you're in an apartment, save yourself from the floor and go upstairs	*Player should realise he made a mistake*
17	Twitter #Biotflood: What are all the firemen doing here at the Biot Hotel, no need for you guys, we're all on the 4th floor drinking Pastis	*Player should realise he made a mistake*
18	Official msg: 3 people trapped in a flood at Marine Land	*Inside of floodable area. Player may send resources*
19	Official msg: 2 people confirmed dead at the Town Hall	*Outside of floodable area: should be a surprise to player*
20	Official msg: 5 people trapped by flood at the Town Hall	*Outside of floodable area: should be a surprise to player*
21	Twitter #Biotflood: All this rain is good for the ducks!	*Junk Tweet*
22	Twitter #Biotflood: Just got a message from my gran in the Retirement Home, water is coming through their door.	*Player should attend to those vulnerable*
23	Twitter #Biotflood: Help us! Retirement Home is flooding!!!!!	*Player realises he has overcommitted resources*
24	Twitter #Biotflood: Too much for me I'm off to the	*Set of tweets to raise*

	evacuation centre, who's coming?	*player's concern*
25	Twitter #Biotflood: re,: Evacuation centre, I'm coming	*Set of tweets to raise player's concern*
26	Twitter #Biotflood: re,: Evacuation centre, me as well!	*Set of tweets to raise player's concern*
27	Twitter #Biotflood: re,: Evacuation centre, I'm coming with all my family	*Set of tweets to raise player's concern*
28	Official msg: Is an additional Evacuation Centre required. Current centre reaching full capacity	*Player may consider opening another centre*
29	Twitter #Biotflood: The flood is really high, never seen this before	*Junk Tweet*
30	Twitter #Biotflood: Due back in Biot this evening, heard on the news that it's flooded, any truth in that?	*Junk Tweet*

At the end of the game, a debriefing session happens. The game can facilitate this activity because all of the player's actions are stored together with the time that they happened. This allows the debriefer to important errors in the player's strategy.

Only when the game has finished, the player can reveal the actual flood map. This map shows the real flood situation, which as in the real situation, was not available during the management of the flash flood. The real flood map is shown below!!!!!!!!!

2. Exploration de l'espace des paramètres (optionnel)

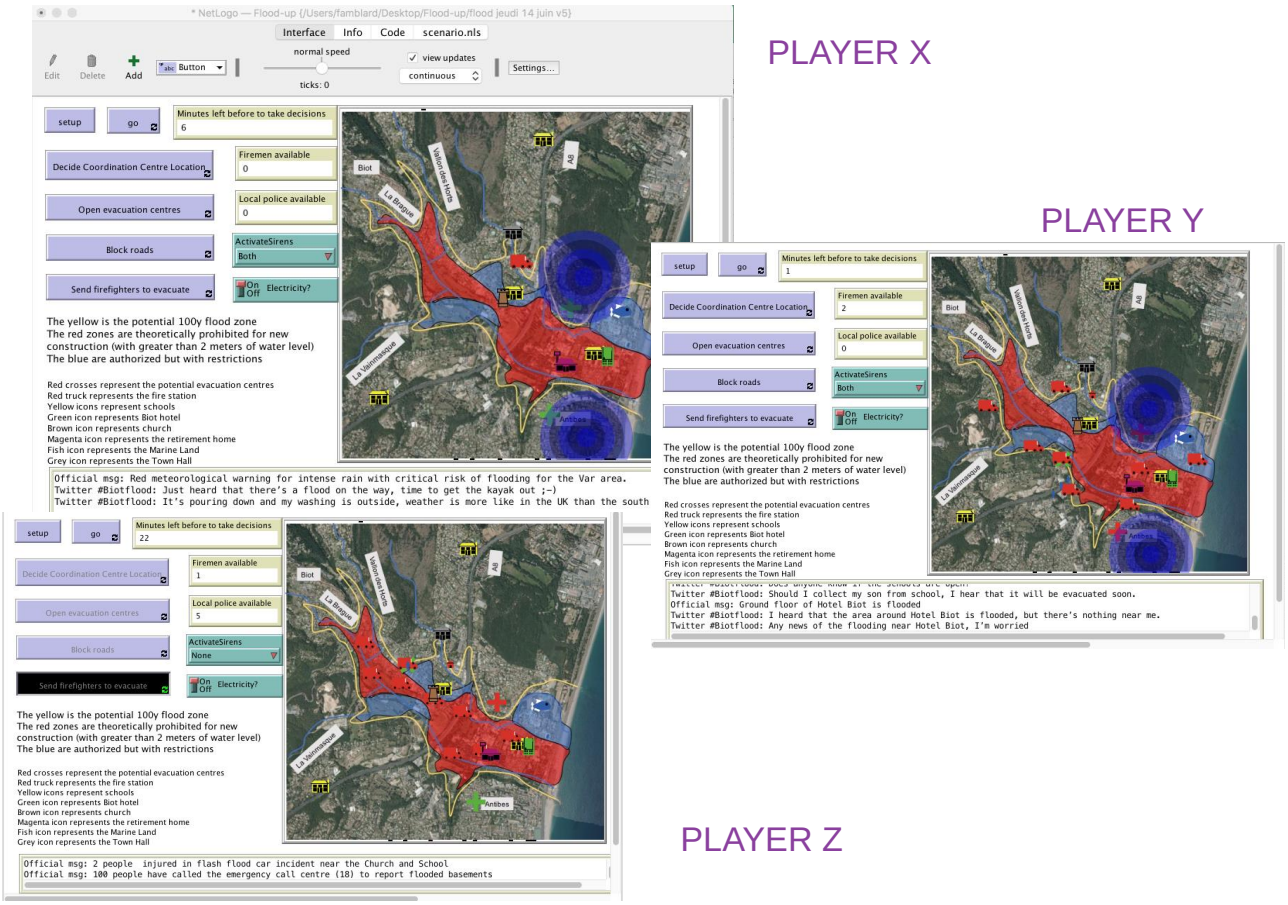
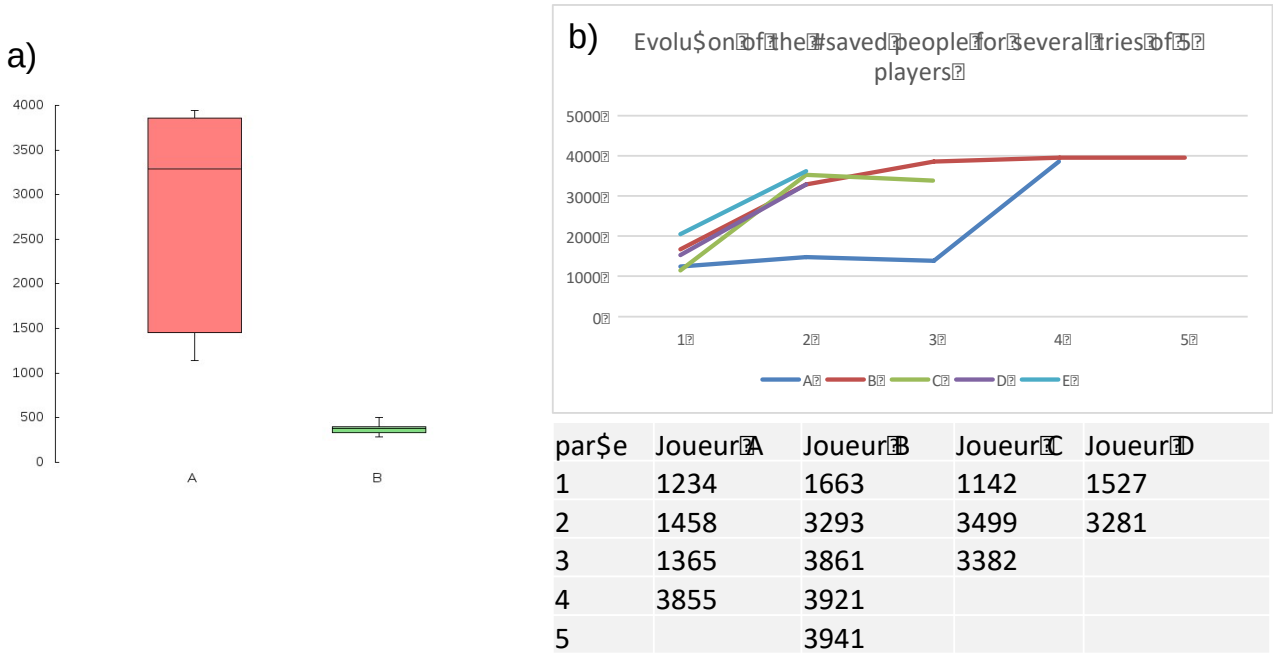


Fig. 9 Game implematentions played by different players. A variety of strategies is observed depending on the "manager's" decisions.

The diagram below (Fig. 8b) shows the increase in the number of lives saved after players had played the game several times. Note that the number includes citizens that were already in a safe situation, for example by being far away from the flood site.



par$e	Joueur A	Joueur B	Joueur C	Joueur D
1	1234	1663	1142	1527
2	1458	3293	3499	3281
3	1365	3861	3382	
4	3855	3921		
5		3941		

Fig. 10 Fist data gathered from different players indicating a) and b) the evolution of the total number of safe citizens as the played games increase.

E - Conclusion

Early in the design process the learning outcomes for the player were defined. These are listed below and represent what we want the player to learn by the end of several rounds of playing the serious game. The right-hand column shows how the game (including the scenario messages) achieve these outcomes.

Learning Outcome	Achieved in the game by

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Don't cut the electricity too early	Sirens that warn the population of the danger will not work if the emergency manager took the decision to cut electricity. The 'Electricity? (On-Off) button is shown in the interface, possibly tempting the player to cut the electricity.
Don't cut electricity too late (it will damage the electricity substations - transformers - and cost $$$ to repair)	Because we keep a track of actions and their times and the actual flood area in the game, we can see if the electricity sub-station is flooded. In the debrifing session, this inforlation is revealed.
Don't put the coordination centre in a floodable area, put it close to the flood, but not in an area that could flood)	The choice of where to put the coordination centre is left to the player. After the game we can reveal if the centre was in an area that eventually flooded.
First define where to put your coordination centre	The introduction to the game is displayed on the initial screen. This was done to help the player with his/her first action.
Don't make all of your decisions on just the floodable area – the flood when it happens could go anywhere!	Scenario messages which make the player realise that they may have made a mistake: 18, 19, 20
Take into account flood reports from citizens, but be careful of the trustworthiness of the source. Identify contradictory or junk information, etc. quickly	Scenario messeges where the user must evaluate the significance of information coming from social media: 2,3,5,12,13,14,15,21,24,25,26,27,29,30. Note that messages encourage the user to develop anticipatory behaviours.
Make sure that you alert all citizens (use sirens)	Scenario messages: 1 and 7 encourage the user to notify citizens by pressing the « ActivateSirens » button on the game interface
Don't send all of your resources to areas that are floodable (misallocation of resources. Have a back-up plan (hold some resources back or know that some resources will return to base very soon)	Scenario messages: 22 and 23. By this time most, if not all of the resources will have been assigned and unavailable.
Give priority to vulnerable citizens (schools, retirement homes)	Scenario messages : 6, 9, 10, 22 and 23
Give advice to citizens to go upstairs if possible (fewer resources devoted to evacuation). Don't attribute resources to	Scenario messages: 11, 16, 17. Messages 16 and 17 will hopefully make the player realise that he has made a mistake in

people who can potentially help themselves	sending resources.

F – Perspectives (Optionnel)

Currently the model takes into account the impacts on the health of citizens (injury/death). The impacts in terms of damage to buildings or the city's infrastructure are not yet considered. Likewise, citizens are assumed to be inside buildings at the start of the game, they then flee or evacuate by themselves (or with the aid of firemen); at this point they are on pathways and eventually on the road network. A more realistic approach would be to initially place some agents on the road network. Although human behaviour has been taken into account in the game, for example a person will flee if a flash flood is proximally close, it is always possible to add more realistic behaviours, for example having a family evacuate together. In addition, communication between citizens could be improved to simulate people telephoning each other for information. Although we imitate people posting on social media by showing Twitter messages in the scenario that influence the player, it would be more realistic if the scenario was dynamic so that the messages occur as a consequence of the player's actions in the game. Finally, a major weakness, but one that was due to the very short design and implementation time is validation and evaluation. Validation could be done by working with emergency managers to assess the reality of the model. In terms of evaluation of the serious game, a questionnaire needs to be developed to assess how the stress and trust in the player's actions evolve after repeatedly playing the game.

G - Bibliographie

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