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Na-Tech Risk: a New Challenge for Local Planners

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The adaptation to climate change in terms of national legislative actions, compensation mechanisms, sectorial risk guidelines is slowly proceeding among EU member states; in this context, local land-use planners lack of adequate tools to properly face Climate-related events. In particular, as far as it concerns NaTech risk, the effective implementation of dedicated measures at local level is difficult to reach; also, the methodologies elaborated till now rarely focused on the management of NaTech risk from the point of view of local urban and land-use planners and managers.
An easy-to-use NaTech indicator is here proposed, aiming at providing Local administrations with a survey of the industries exposed to NaTech risk on their territory, and to signal possible critical situations to be managed. The first step for the development of the indicator consists of a questionnaire aimed at identifying potential vulnerable items and hazardous substances detained; then, both items and substances are rated to obtain a classification of potential NaTech vulnerability.
NaTech indicator could be useful to increase the awareness and preparedness of public administrator and planners towards the increasing probability and impact of Na-Tech events; it has the advantage to be easy to use for not expert users and can guide the decision-makers in identifying the most vulnerable Na-tech areas in their territory. The NaTech indicator can be integrated with further in-depth studies, including i.e. the Integrated Quantitative risk-assessment.

1. Introduction

Climate change is progressively enhancing the magnitude and recurrence of natural events (i.e. floods, storms, heat waves); despite strategies of adaptation and mitigation are on progress worldwide, in Europe the implementation of a dedicated legislative framework deeply differs between the Member states. Climate change has repercussions on the industrial sector too: together with worldwide industrialization, population growth, and community densification, climate change is expected to bring an increase in the number and magnitude of the so-called NaTech events (Krausmann et al., 2017). NaTech is the acronym for NAtural disasters triggering TECHnological accidents and it is adopted to define industrial accidents that are provoked by the impact of a natural event on the installations (a recent and well-known example of NaTech event is the Fukushima Daiichi nuclear disaster). NaTech accidents have proper features as multiple releases and escalation and cascading events on lifelines and networks (OECD, 2013).
The Seveso-III Directive required to consider NaTech scenarios in the Safety reports of the Seveso plants; however, specific guidelines for industry and regulatory authorities are not yet available (Krausmann et al., 2017). Methodologies for the analysis and assessment of possible NaTech scenarios have been studied and proposed for many years, however the importance to include them in the territorial and emergency planning still seem not recognized (Krausmann et al., 2011, Salzano et al., 2013).
The present study aims at increasing the awareness about NaTech risk among the local planners, providing an easy tool to support planning and decision-making of local authorities with respect to NaTech events.

2. Local planning approach to risk and adaptation

The impacts of climate change are obviously experienced at a local scale (Measham et al., 2011), therefore local authorities are those expected to firstly intervene for emergency management and for the implementation of structural measures able to mitigate or avoid the risks. Local authorities could play an important role in this

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sense through their territorial planning powers, and through the local emergency planning; however, 'the planning field scarcely involves itself with disaster management' (Wang, 2012).
The growing frequency of extreme events due to climate change requires new instruments for adaptation and mitigation of the risks, that should integrate land-use planning and disaster management, with a shift from emergency response to hazard mitigation (i.e. through urban policy, land use strategy, watershed management etc.). Despite the EU Adaptation Strategy for Climate in 2013 (EU Commission, 2018) pushed the Member States to draft national adaptation plans and policies, at a local level several criticalities can be encountered:

1) When national legislations lack of operative guidelines and actions for the local-scale adaptation, this affects the legal mandate of local governments. Therefore, a lack of attention to climate change at the higher regulatory hierarchies leads to lack of appropriated tools and strategies at the local level (Amundsen et al., 2010). The difficulty in identifying the authorities in charge for the actions related to adaptation constitutes a further obstacle towards the adoption of structural prevention measures and prompt emergency intervention. Lumbroso and Vinet, 2012, evidenced responsibility gaps in flood management, that decreased the efficiency of risk management. Measham et al., 2011, affirmed that local governments are operating within an 'institutional void', where the complexity of governance makes difficult to clearly decide institutional roles and responsibilities, resulting in ineffectual policy development.
2) Local governments can have an inadequate technical preparation to properly deal with Climate change assessment and adaptation; the forecast and mitigation of the effects of Climate-related events often require a multidisciplinary approach and a level of expertise that could lack at local level. As far as it concerns NaTech events, public decision-makers evidenced the need of raising awareness and improving risk communication at all levels of government, also reporting the lack of specific technical codes and guidelines for NaTech risk assessment (Krausmann and Baranzini, 2012). In addition, the absence of adequate NaTech risk maps impedes an informed decision-making on land-use planning and emergency-management (Krausmann and Baranzini, 2012). Lumbroso and Vinet, 2012 denounced that: 'too few people are being trained to replace the ageing skilled workforce, and too few are acquiring the technical and managerial skills required to get full value from new techniques and technologies.' The lack of technical capacity can discourage the use of new methods that are not viewed as being 'mature'; also, some organizations may suffer from poor intelligence gathering and processing or even a 'it can't happen here' mentality.
3) Risk is a dynamic factor, therefore the plans for land-use organization and emergency management should be dynamic too; however, Prabhakar et al., 2009, denounced that 'regular revision of disaster management plans is far from reality in many countries, as hazard and vulnerability assessments are done when funds are available […] and any revision is not possible after the termination of the [funds]'. Many revisions were done only after a major disaster has struck'. The availability of the funds deeply influences the possibilities of local authorities to update their plans and develop an adequate preparation to face risks; in the end, climate adaptation is in competition with many other needs that appear more urgent. Measham et al., 2011 noted that even when the need for climate adaptation is acknowledged in the conceptual realm of strategic planning, it results underrepresented when it comes to allocating scarce resources.

3. NaTech indicator for local planners

The adaptation to climate change in terms of national legislative actions, compensation mechanisms, sectorial risk guidelines is proceeding with different velocities for EU member states, and the effective implementation of dedicated measures at local level is an objective difficult to reach even for the most advanced countries. In fact, as demonstrated in Par. 2, at the moment local land-use planners result scarcely aware and prepared to face the risks related to Climate change. As far as it concerns NaTech risk, Krausmann et al., 2017; Cardarilli et al., 2019 noticed that the studies on the direct and especially indirect impacts to the communities, economy, and environment are scarce, and the resilience aspects are not accounted for. In addition, the methodologies elaborated till now are mainly focused on the definition of the scenarios and mitigating actions in charge to company managers, but the management of NaTech risk was rarely analysed from the point of view of local urban and land-use planners and managers.
The methodology proposed in this paper, named 'NaTech indicator', was developed with the specific aim of increasing the awareness of local planners and administrators about NaTech risks, providing them with a simple and economic tool to quickly identify potential sources of Natech events and be able to carry out opportune protective actions. The NaTech indicator is an indicative method addressed to professional and political figures and roles that traditionally are not involved in industrial risk assessment; therefore, the tool only requires a guided attribution of ratings to factors related to the company, trying to avoid subjective

evaluations that could confuse the users. The chosen approach cannot substitute quantitative risk analysis but, in the absence of a harmonized legislation concerning NaTech risk and its territorial relapses, it aims at filling the existing gaps at local level, providing a first screening of the NaTech risks. In-depth investigations are demanded to more specific and detailed quantitative analysis on the identified plants.

'NaTech indicator' non only considers the NaTech risk related to Seveso plants, but includes non-Seveso industries, with particular attention for the environmental aspects: in fact, NaTech events can derive also from moderate natural events and plants considered 'not hazardous'. The plants that are not classified as Seveso could in any case detain high quantitative of hazardous substances, but they are subjected to minor controls and obligations, i.e. they do not report to the authorities information on the quantity of hazardous substances detained, the protective measures adopted etc. Some traces of their activities can be found only for plants that are subjected to IEA (Integrated Environmental Authorization) or authorizations for the discharge in public water. In Italy, Regione Piemonte (2010) imposed to take into account for the safe planning related to industrial accidents non-Seveso plants too; in particular, the category of the Sub-threshold Seveso was established to indicate plants detaining the 20% of the threshold for lower-tier instalments imposed by the Seveso III directive. This concept was fully recovered for the definition of the 'NaTech indicator'.
The following sub-paragraphs presents the steps for the calculation of the NaTech indicator.

3.1 NaTech questionnaire

The NaTech questionnaire was already proposed in Pilone and Demichela (2020) and aims at collecting detailed information on the assets, substances and storage of the plant; while Seveso instalments usually report detailed descriptions on the quantity of substances, scenarios and preventive and protective measures in the Safety reports or Notification, this information is almost unknown for non-Seveso plants.
The NaTech questionnaire is composed by three sections that investigate respectively: 1) storage methods and items potentially exposed to NaTech risk; 2) past accidents occurred on the site, both related to internal causes and external events; 3) short analysis of the environmental impact on the surroundings.
The preventive and protective measures adopted by each plant are not investigated in this Questionnaire and by the NaTech indicator but demanded to the in-depth investigations that should follow the application of the methodology. In fact, the common protective and preventive measures adopted could not be effective to adequately prevent or protect from the consequences of multiple cascading events as Na-Tech ones, and their efficacy cannot be correctly evaluated by not-expert users as the Land-use planners; therefore, this parameter can be only considered case by case during the further investigations on the plants identified as critical.

3.2 NaTech indicator

The calculation of the NaTech index derives from two key parameters, that are essential to define the potential NaTech vulnerability of the analysed plant: 1) Presence of items that are particularly vulnerable in front of external events (for content, shape, position); 2) Type and quantity of detained Hazardous substances.

FACTOR A: Vulnerable items → The list of the items potentially vulnerable was selected on the basis of the post-accident analyses made by Antonioni et al., 2009, and Krausmann et al., 2017, Chiaia et. al, 2016; as already reported, tanks are identified as the more vulnerable item towards any type of event. As far as it concerns the earthquakes, the tallest equipment (i.e. chemins, distillation towers, torches), even when they are not detain hazardous substances, risk to collapse on other items provoking cascading events.
Based on the above-mentioned considerations, the following equipment was selected:

1. Basins for water treatment;
2. Atmospheric or pressurized tanks;
3. Underground tanks;
4. Tall structures (distillation towers, chemins, etc.);
5. Basins and other process equipment;
6. Storage of hazardous raw materials (cylinders, big-bags, etc.).

The users are required to assign a rating to the Factor A (Vulnerability of the items), verifying the presence /absence of the vulnerable equipment and its position, and then evaluating the possible interaction with natural hazards or other threats (i.e. obsolescence). Factor A is calculated compiling the following table 1, according to the following process:

- indication of the position of the item analyzed (I = Inside, O = Outside);
- Assignation of the rating related to the presence or absence of each item (0 = absent, 1 = present);
- Assignation of the rating related to the presence or absence of each hazard (0 = absent, 1 = present);

- Calculation of the interaction between hazards / items, through the multiplication of the ratings of the row 'Items' with those of the column 'Hazards'; the position of an item inside the plant could entail the absence of interactions.
- Calculation of the Factor A, summing up the results of the interactions for each item-hazard.

Table 1 below exemplifies the calculation for Factor; it represents the extreme case of a plant owing all the vulnerable items, located outside (O) and exposed to all the possible hazards. This allows to assess the maximum value reachable for Factor A, corresponding to 26.

Table 1: calculation of Factor A: Vulnerable Items

NATECH VULNERABLE ITEMS →		Water treatment basin	Atmospheric pressurized tanks	Underground tanks	Tall structures	Basins, process equipment	Hazardous storage
Position of the items→	Inside (I) Outside (I)	(O)	(O)	(O)	(O)	(O)	(O)
Hazards↓	Ratings↓→	1	1	1	1	1	1
Earthquake	1	1	1	1	1	1	1
Flood	1	1	1	No correlation	No correlation	1	1
Storm	1	1	1	No correlation	1	1	1
Fire	1	No correlation	1	1	1	1	1
Obsolescence	1	1	1	1	1	1	1
Total ratings→		4	5	3	4	5	5
FACTOR A = 26							

__FACTOR B: Hazardous substances__ → Factor B is related to the Type and Quantity of hazardous substances detained by the plant; the substances considered are those listed in the Annex I, Parts 1 and 2 of the Seveso III Directive, that define the thresholds for the classification as Seveso lower-tier or upper-tier instalment. The Type and Quantity of hazardous substances have to be rated, to define the hazardousness of the plant; the values of the ratings were designed by the authors through multiple experiments on already known industries and aim at correctly take into account the non-Seveso industries and the environmental aspects.

As far as it concerns Factor B1 - Type of substance, the users shall identify to which Hazard categories (Regulation (EC) No 1272/2008), the hazardous substances of the plant belong:

- Section 'H' – HEALTH HAZARDS: Toxic substances, carcinogenic substances
- Section 'P' – PHYSICAL HAZARDS: Explosive, flammable, oxidizing, pyrophoric sub-stances
- Section 'E' – ENVIRONMENTAL HAZARDS

Then, the users attribute the ratings reported in the following Table 2: i.e if the plant detains toxic substances, the rating will be 3. Please note that Factor B1 distinguish substances into 'Hazard for people' and 'Hazard for the environment', in order to highlight and make clear the possible environmental impact of the plant.
Factor B2 is related to the Quantity of substances detained: for each hazardous category, the users shall identify if it overcomes the Seveso thresholds or not. This means that a plant could overcome the Seveso thresholds for the category E – Hazard for the Environment, remaining under threshold for all the other categories. The ratings to be attributed are defined in Table 3, reported below.

Tables 2 and 3: rating of Factors B1 – Type of substance and B2 – Quantity of substance

FACTOR B1 Hazard for people			Hazard for the environment		
Section	Effect	Rating	Section	Effect	Rating
H	Health hazards *Toxic*	3	E	Hazardous for the environment	3
H	Health hazards *Carcinogenic*	2,5	-	Other substances	0,5
P	Physical hazards	2			

FACTOR B2 The quantity of substances belonging to cat. H / P / E is:	Rating
> Seveso lower-tie threshold	1
> 20% of the threshold for lower-tie instalment (Sub-threshold Seveso)	0,6
< 20% threshold lower-tie instalment of Seveso III directive)	0,2

NaTech indicator → Factors A, B1 and B2 shall be multiplied to obtain: 1) the NaTech indicator for People, indicating the dangerousness for human beings and human activities; 2) the NaTech indicator for Environment, representing the potentiality of pollution. The NaTech indicator is calculated according to the following formula:

$$NaTech\ Indicator = A\ Factor\ x\ \left(\sum n\ \ B1\ Factor\ x\ B2\ Factor\right) \quad (1)$$

The following Tables 4 and 5 show how the calculation of the NaTech indicators is obtained, once again representing a hypothetical Seveso plant having all the vulnerable items, and overcoming Seveso thresholds for all the types of substances. Therefore:

- Factor A = 26 (see Table 1);
- Substances belonging to section H (Health hazards - Toxic) → Factor B1 = 3 (present) x Factor B2 = 1 (overcoming Seveso threshold);
- Substances belonging to section H (Health hazards - Carcinogenic) → Factor B1 = 2,5 (present) x Factor B2 = 1 (overcoming Seveso threshold);
- Substances belonging to section P (Physical hazards) → Factor B1 = 2 (present) x Factor B2 = 1 (overcoming Seveso threshold);
- Substances belonging to section E (Hazardous for the environment) → Factor B1 = 3 (present) x Factor B2 = 1 (overcoming Seveso threshold);
- Other substances → Factor B1 = 0,5 x Factor B2 = 0,2 (no thresholds applied).

Tables 4 and 5: Calculation of NaTech indicator for People and NaTech indicator for Environment

NaTech indicator for People		
Factor	Rating attributed	
A		26
B1	3 (H – Toxic)	3 x 1 = 3
B2	1 (> Seveso	
B1	2,5 (H – Carcinogenic)	2,5 x 1 = 2,5
B2	1 (> Seveso)	
B1	2 (P – Flammable)	2 x 1 = 2
B2	1 (> Seveso)	
Total = 26 x (3 + 2,5 + 2) = 195		

NaTech indicator for Environment		
Factor	Rating attributed	
A		26
B1	3 (E – Hazardous for the environment)	3 x 1 = 3
B2	1 (> Seveso)	
B1	0,5 (Other substances)	0,5 x 0,2 =0,1
B2	0,2 (no thresholds applied)	
Total = 26 x (3 + 0,1) = 81		

The values reported in Table 4 and 5 are the maximum NaTech indexes that can be reached; however, it was necessary to establish an alert threshold to clarify when a plant effectively represent a threat for NaTech and could need further investigations, i.e. on the state of items / storage / measures of prevention and protection adopted. The threshold was established through experimental proofs on known existing plants, with the aim in any case to keep it as low as reasonably possible in order to include even apparently safe situations. In fact, as already specified, the non-Seveso industries could represent a serious hazard, often neglected. In the end, the alert thresholds adopted were: 27 (NaTech Indicator for people); 11 (NaTech Indicator for Environment).

3.3 Application

NaTech indicator is based on an intuitive rating system, whose values were multiply tested on already well-known situations to verify their capacity to return feasible results. The tests were carried out on Seveso and Sub-threshold Seveso plants in Piedmont, whose information about hazardous substances and storage were already available, because the authors contributed to the draft of the E.R.I.R. plans (Plan for the area around Seveso plants). The final version of the rating and thresholds presented in this paper was the one that returned the results more in line with the real situation of the plants analysed in terms of potential hazard. In particular, since Piedmont in particularly vulnerable to flood events, the NaTech indicator correctly pointed out the NaTech potentiality of plants having sensitive items located outside.

NaTech indicator first test was made with the cooperation of a group of 18 professionals (planners and other figures dealing with land use regulation) during a Masterclass organized by Politecnico di Torino. The learners were asked to develop the entire process of calculation as explained in Par. 3.2, using a simple case-study; in the end, they answered to a questionnaire to evaluate the proposed approach, its usability, and possible difficulties. The learners find interesting and useful the methodology, however, they evidenced some difficulties in its use, not properly related to the methodology itself, but to the categorization of the substances for Factor B1, to which they were not used. This partially affected the correctness of the final results for some participants.

4. Conclusions

The test of the methodology with the administrators and local planners, mentioned in Par. 3.3., returned an interesting result: nobody knew NaTech risk before the class. This confirmed the general backwardness concerning NaTech risk for planners and decision-makers dealing with land-use organization, as mentioned in Par. 2. NaTech indicator can constitute a first step of awareness, allowing the users to easily identify the problematic situations on their territory: it has low application cost, and can be managed by users that are not specifically expert in the multi-risk or NaTech disciplines. These aspects could grant a major spread and adoption among local administrations. More detailed methodologies for NaTech risk assessment shall be involved in a second phase, after that the major criticalities have been identified, to confirm the hazard and evaluate the efficacy of the preventive and protective measures adopted by the plant.
The test of the NaTech indicator with the control group of local administrators suggested possible improvements to simplify the application of the methodology: considering the scarce competence in the matter of risk assessment, a detailed introductory course on the classification of the substances, the Seveso thresholds and finally, the calculation of the NaTech indicator, should always precede the application of the methodology.

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