International Journal of Disaster Risk Reduction 31 (2018) 770–780

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Capacity building measures for chemical accident prevention and preparedness: Benchmark of EU neighbourhood countries

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ARTICLE INFO

Keywords:
Capacity building
Chemical accidents prevention and preparedness (CAPP)
EU neighbourhood countries
Survey profiling

ABSTRACT

The purpose of this study is to review and present the contribution of the Joint Research Centre of the European Commission to the development of a new methodological approach for measuring the effective capacity of national programmes aimed at reducing the risk of chemical accidents. This new methodology is specifically intended to enable comprehensive assessment and monitoring of the progress of European Union (EU) Neighbourhood Countries in building capacity to implement effective chemical accident prevention and preparedness (CAPP) programmes. The paper describes indicators developed for the EU Neighbourhood Countries project for Seveso capacity building, in which the Seveso Directive experience in the EU is the reference model for capacity building efforts and measuring progress. Measurement of key programme elements, implementing practices, competences, and resources was operationalized into a broader survey of the national chemical accident risk reduction programmes and strategies. The responses to selected questions were then aggregated into three capacity building indices. This innovative approach illustrates how the specific indices may be applied to measure progress, benchmark against other countries and identify trends in capacity building growth. Implications and benefits of the capacity building indices are discussed in terms of their relevance as leading indicators in developing capacity building strategies in specific countries and regions. It is noted that the same framework can also be used to measure capacity building towards other sustainability goals, based on specific data availabilities.

1. Introduction

While there has been considerable work establishing theoretical frameworks for capacity building measures of all kinds, there is little documentation of approaches that specifically address management of chemical accident risks. There are some documented applications associated with environmental risk, including environmental noise [23], and integrated environmental risk assessment (including disasters) [11], that are somewhat relevant, but as models for chemical accident risk management they are incomplete. On the other hand, the OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response [8,9] describe the key functions and roles of the institutional actors across society, creating a theoretical framework for capacity building targets.

The UNEP Flexible Framework for Chemical Accident Prevention and Preparedness further specifies the essential ingredients for effective governance of chemical accident risks [19]. The accompanying Implementation Support Package to the UNEP Flexible Framework also contains lists of questions for a self-assessment of the country situation to determine the starting point for improving the chemical accident prevention and preparedness programme [20].

Capacity building is a term derived in many facets from the international community's efforts to address the full range of sustainable development issues. As a leading example, Agenda 21 of the United Nations Conference on Environment and Development states that *"the ability of a country to follow sustainable development is determined by the capacity of its people and its institutions as well as by its ecological and geographical conditions"*, Chapter 37 - Agenda 21″ [18]. The same source refers to capacity building as *"…the country's human, scientific, technological, organizational, institutional and resource capabilities"*.

Experts have generally defined capacity building as either a *product* if the focus rests upon the term "capacity" (e.g., the requisite of resources, tools and competencies) or a *process*, if the focus is on the term "building" (e.g., the continuous process and action to support

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https://doi.org/10.1016/j.ijdrr.2018.07.023
Received 12 March 2018; Received in revised form 26 July 2018; Accepted 26 July 2018
Available online 27 July 2018

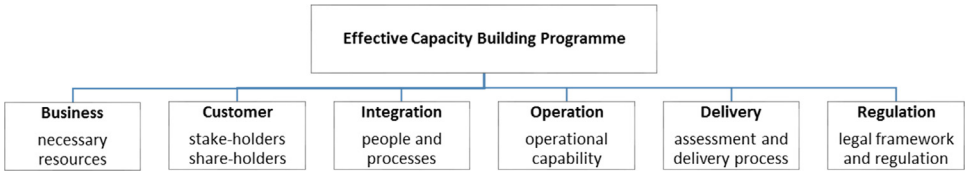


Fig. 1. A conceptual hierarchical process model [22].

development of capacity). The concept of capacity building in this paper has been defined conceptually as "the extent of existing capacity in the country to implement an effective chemical accident prevention and preparedness (CAPP) programme ([1], pp.19).

In addition, previous work by Van Wijk et al. [22] established a hierarchical process model for capacity building that could be adapted specifically for CAPP capacity building in EU Neighbourhood Countries. This model is made of a hierarchically structured set of processes distributed at different levels. The model provides concrete measures for different domains such as human, financial and physical resources and the legal and administrative infrastructure. All of them are necessary for implementing an effective (and sustainable) government programme for chemical accident risk reduction, as shown in Fig. 1. The hierarchical process model supports a community-based approach since it emphasizes the ability to deliver services without reference to how those services are delivered.

The formal recognition of capacity building as the foundation of sustainable development aid led eventually to the concept of measuring the outcomes of sustainable development measures. In establishing practical implementation guidelines for Agenda 21, a consensus emerged that capacity building should be community-based and results-oriented. The Paris Declaration on Aid Effectiveness [15] and the Accra Agenda for Action (2008) resulting from a multilateral initiative of the OECD Development Aid Committee (DAC), give support to a practical, action-oriented roadmap to improve the quality of aid and its impact, stressing, inter alia, the importance of capacity building using country-specific approaches and progress measurement.

The Paris Declaration stresses that aid efforts should *"Endeavour to establish results-oriented reporting and assessment frameworks that monitor progress against key dimensions of the national and sector development strategies."* The Accra Agenda additionally highlights that "*Without robust capacity – strong institutions, systems, and local expertise – developing countries cannot fully own and manage their development processes."* In guidelines developed by the OECD DAC in 2006 [10], it is noted that "*The "best fit" approach to capacity development … calls for a systematic effort to think through what might work in the particular circumstances,*" and that *"It is important for practitioners to begin by asking the question 'capacity for what?' and focus on the specific capacities needed, pp. 8"*

2. Scope of CAPP capacity building

The CAPP capacity building presented in this paper targets capacity building for those countries external to the European Union, as shown in Fig. 2. This project supports the European Commission "Seveso ENPI" initiative that aims to assist European Union (EU) Neighbourhood Countries in improving their approaches to chemical accident risk management in alignment with the EU Seveso Directive (2012/18/EU) [1].

A methodological approach based on indicators represents a further extension of the evidence-based approach adopted by the INFORM initiative. Launched in 2012 as a convergence of interests of UN agencies, donors, NGOs and research institutions, INFORM aims to establish a common evidence-base for global humanitarian risk analysis to accomplish clearly defined goals [7]. Whereas INFORM indices are a high-level tool for understanding each country's risk of humanitarian crises and disasters of any type, the proposed CAPP indices measure components specific to the risk of chemical accidents.

The proposed CAPP approach takes into consideration a number of findings related to capacity building in disaster risk management fields, in particular:

- Effective capacity building is both systemic (involving systems and linked structural elements) and holistic (addressing the complete system rather than individual components), and thus must address much broader needs than simply governmental or industry competency [3].
- Capacity building should be rooted in a well-researched understanding of the local context to better tailor capacity building interventions [5].
- Data gathering is one of the three pillars for "bringing disaster risk reduction and development concerns closer together" ([21], pp. 2).
- The definition of capacity goals should be maximally related to the nature and magnitude of risk and vulnerability in a specific country or region [3].

Experts suggest rightly that capacity assessment for disasters should also allow for multi-actor capacity assessment, which is crucial in today's complex society where adverse events or disruptions may spread across sectors and national borders [4]. UNDP also suggests that "Local governments, line ministries of central governments and networks of non-governmental and community-based organisations all have roles to play in the developing of shared reporting conventions and methods that will maximise the amount of data that can be used for strategic policy-making" [21].

Notably, the methodological approach presented here addresses mainly government resources and systems for chemical accident risk reduction. It does not look deeply at other influential sectors such as industry and society at large. As such it could be considered as measuring only part of the disaster risk management system. Other measures could be developed in future that specifically evaluate industry infrastructure and competence and/or the influence of social norms and perceptions related to disaster risk and environmental health and safety.

3. Capacity building in the European Union and neighbourhood countries

The European Commission initiative to support capacity building for Seveso Directive implementation in Neighbourhood countries is a natural outgrowth of JRC's long partnership in Seveso Directive implementation with EU Member States, followed by outreach to new EU Countries prior to accession in the early 2000's, and subsequent bilateral and international collaborations on capacity building in developing countries [24]. However, it goes further than prior capacity building efforts, mainly due to lessons learned from these past experiences but also as a part of the global effort to implement the Hyogo and Sendai Framework for Disaster Risk Reduction [2,16,17]. The European Commission, acting on behalf of the EU, plays a leading role in implementing the Framework through various instruments including the Union Civil Protection Mechanism (Decision No 1313/2013/EU) that supports the Seveso ENPI project.

Effective capacity building should be based on a systematic structured conceptual approach pre-identified by the capacity building team, loosely defined as the main internal actors driving the country's improvement that could also include external experts. It is generally accepted that the overall principles of an effective chemical accident risk

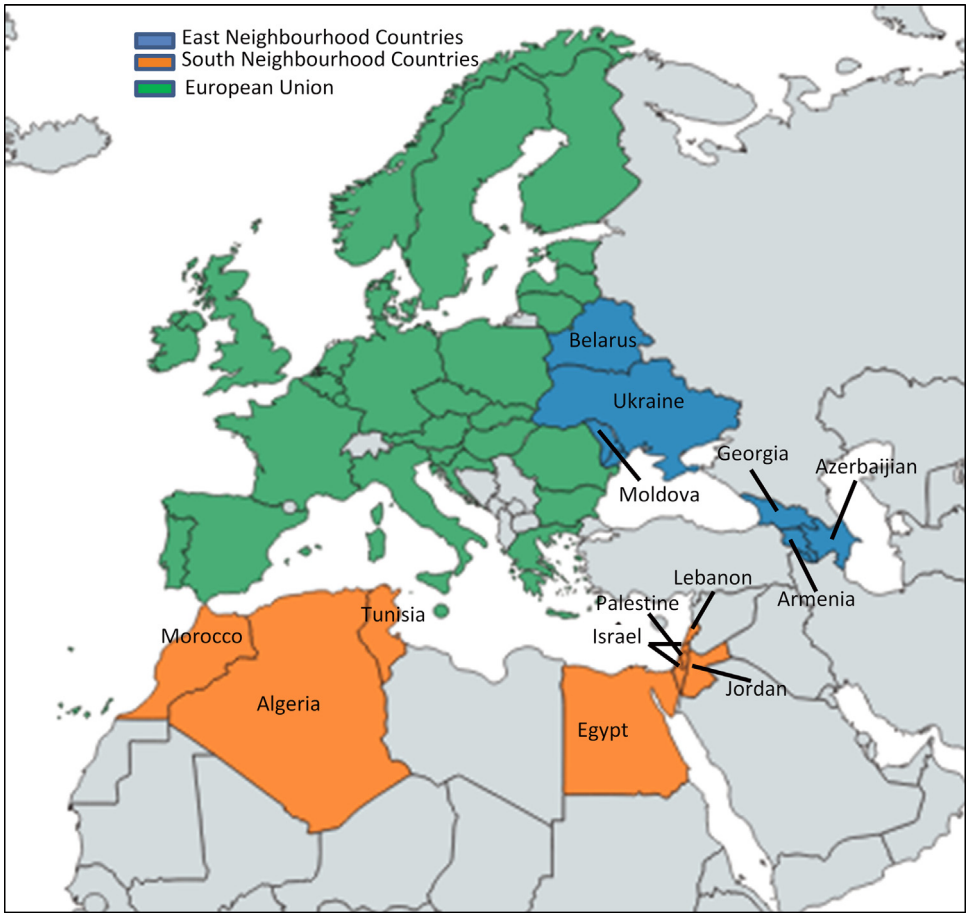


Fig. 2. Countries associated with the Seveso ENPI Project.

reduction programme are embodied in the OECD Guiding Principles for Chemical Accident Preparedness, Prevention and Response, and for this project, the Seveso Directive provides the structured framework for systematic implementation of these principles. Nonetheless, the team should assume considerable flexibility in how to make the concept work for each country following the philosophy of the UNEP Flexible Framework. In practice, once the programme elements are identified, the next step is to examine the country's situation to determine which ones are the highest priorities at the start and, to a large extent, how they can be delivered.

Specifically, the Sendai Framework emphasizes the importance of data collection and measurement for disaster risk management, including capacity assessment. To a large extent, the practice of measuring implementation progress is a long-standing practice in the EU first established within the Standardised Reporting Directive (91/692/EEC). Under the current Seveso Directive legislation, EU Member States are required to submit implementation reports every four years on the basis of an implementation questionnaire. However, the results of these surveys are not normalized or quantified as indicators of implementation capacity or effectiveness. Moreover, the Seveso implementation questionnaire is limited in its application for capacity building in third countries because it assumes that Member States have the minimum competence, resources and infrastructures to deliver Seveso implementation.

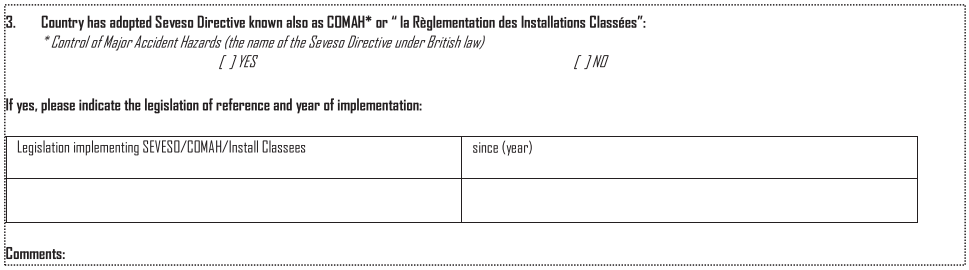
In contrast, CAPP competence, resources and infrastructures in the *EU Neighbourhood system*, the pool of countries bordering the EU Member States, are largely unknown or unclear variables. Thus, there can be no minimum assumptions in regard to the effective *level* of chemical accident prevention and preparedness, and particularly the degree to which sustainable capacity building has occurred in this domain. From an EU perspective, understanding and measuring current capacity levels in EU bordering countries requires exploring levels of competence, resources and infrastructure available in each country with reference to implementation demands of the Seveso Directive model, with the expectation that in many cases, the minimum level could be *zero*.

Moreover, within the EU and the international community, the various attributes that might be measured to uncover and assess systemic strengths and weaknesses in chemical accident risk management are broadly known. However, data gathering to assess capacity building gaps and strengths has until now been lacking. Hence, the Seveso ENPI project sought not only to create a methodology for quantifying capacity building but also to establish a meaningful and repeatable method for collecting the supporting data [1].

3.1. The Seveso ENPI survey

The Seveso ENPI Project started in 2014, and focused on knowledge-gathering activities to establish the country situation in reference to implementation of Seveso Directive principles. A first step in the project was to design and administer a survey, the “Seveso ENPI survey” in order to generate a first *profile* of 14 European Neighbourhood Countries, specifically Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Israel, Jordan, Lebanon, Moldova, Morocco, Palestine, Tunisia and Ukraine countries and regions as depicted in Fig. 2. The survey sought to understand the country's exposure and control measures in place in the face of both chemical and Natech accident risks (i.e, Natural hazard triggered technological accident).

A central element of the first phase of project implementation was data collection through a survey on the individual situation in each



3. Country has adopted Seveso Directive known also as COMAH* or " la Règlementation des Installations Classées":
* Control of Major Accident Hazards (the name of the Seveso Directive under British law)
[ ] YES [ ] NO

If yes, please indicate the legislation of reference and year of implementation:

Legislation implementing SEVESO/COMAH/Install Classees	since (year)

Comments:

Fig. 3. Example of items in Part I (ENPI Survey).

Neighbourhood country to establish a baseline for strategy implementation and more concrete initiatives in the project. Notably, all items of the survey were carefully proposed in JRC as reflections of what is "expected" as relevant for any EU Member State in terms of resources, competence as well as managerial and operational factors deemed important for delivering reliable levels in chemical accident prevention and preparedness. The survey was also deliberately designed to be able to develop capacity building indicators that could indicate positive and negative capacity building trends. The survey approach was modelled on a prior survey conducted by Krausmann and Baranzini [6] to estimate EU and OECD government resources and infrastructure for managing Natech accident risks.

By necessity, the survey aimed to obtain information on a wide range of inputs, including the nature of chemical accidents in the country, the institutional framework in place for enforcing chemical risk management, to the technical and practical competency requirements both at regulatory and industrial level [1,22]. Through the survey responses, it was expected that the project could have a more accurate perspective in regard to:

- The scope and requirements of the legal and regulatory framework of each country and how closely it currently approximates the Seveso Directive scope and requirements.
- The key government authorities associated with oversight and enforcement of the CAPP programme elements.
- Specific elements of a CAPP programme that are well-implemented and represent good practice.
- Gaps and limitations in the CAPP programme, in terms of either the legal framework or its implementation and enforcement.
- Knowledge and resources currently available to the government to address chemical and Natech accident risks.
- A government perspective on the adequacy of the legal framework and its enforcement, and in particular, future priorities for strengthening the CAPP programme.

The survey specifically targeted the country's leading competent authority (or authorities) involved in chemical and Natech accident risk reduction activities, chosen by the country itself (through the department charged with international relations). It asked for a wide range of objective and subjective information to gain a richer understanding of the situation regarding specific implementation elements. The survey was administered over the course of 6 months, a fairly short time frame considering the size of the questionnaire, the technical and informational content demands, as well as in many cases the co-ordination effort needed to respond among different ministries or departments with adequate knowledge.

The ENPI survey was designed both for highly structured rich quantitative and qualitative analyses about a wide-range capacity building arguments. The complete ENPI tool is reported in its entirety in Annex 1.

The content of the survey was based on the joint publication of the EU and the UN Economic Commission for Europe (UNECE) summarising the various hazard rating systems used in the EU, the European Economic Area (EEA) and Eastern European countries [13], the self-assessment questionnaire in the UNEP Flexible Framework Implementation Support Package [20], and a prior survey assessing the status of Natech risk management in OECD and EU countries [6].

Also, the survey took into account the expertise of the JRC and other experts in collecting similar information for capacity building projects in EU Accession and Candidate Countries outside the EU prior to 2004.

3.1.1. Structure of the survey

With these inputs in mind, a highly structured survey of 54 items (plus 3 Background items) was organised and split into five distinct topics that all together were designed to cover all the core elements necessary for achieving a first preliminary understanding of the strength and weaknesses of any national chemical accident prevention and preparedness programme. The five ENPI Survey sections with their relative number of Items are:

Part I -Legislative and Regulatory Context(9 items)
Part II -Enforcement(4 items)
Part III - Accident Awareness and Competence(24 items)
Part IV - Risk Reduction Measures(7 items)
Part V - Needs and Limitations(7 items)
[Part VI – Background Information(3 items)]

Part I - Legislative and Regulatory Context asks about legislative and regulatory instruments, including scope and specific requirements with an aim to understand legal drivers for chemical accident prevention and preparedness in the country and how closely they approximate Seveso Directive scope and requirements. Exemplary items for this section (binary and open ended items) are shown in Fig. 3.

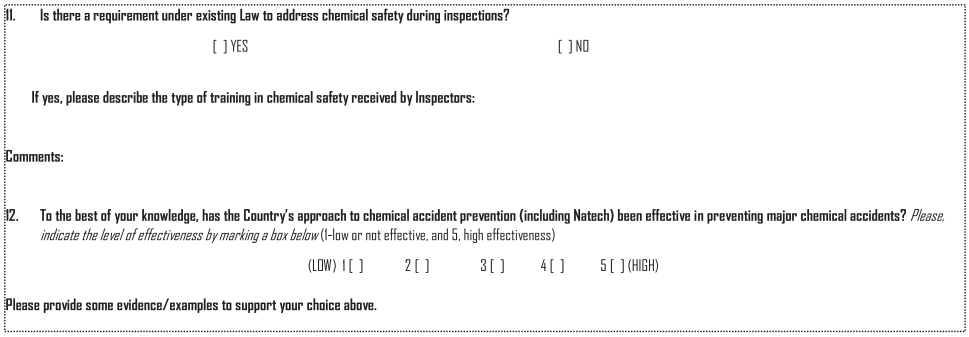
Part II - Enforcement aims instead to identify enforcement responsibilities associated with the legislation, in particular, the frequency and type of inspections and the authorities involved. Two exemplary items (binary, ordinal and open ended items) are presented in Fig. 4.

Part III - Accident Awareness and Competence is to explore and understand the country's situation regarding to accident history, potential exposure to accident risks as well as resources available to address risk management needs (availability of relevant experts, knowledge and data). Specifically, a first section asks about the country's experience and awareness of chemical and Natech accidents.

A second part inquires on what major chemical accident risks have already been identified by national authorities (e.g., types of industries and substances). A third final section covers competencies and risk assessment tools availabilities. An example question for Part III (6-point Likert with open ended section) is depicted in Fig. 5.

Part IV - Risk Reduction Measures identifies various national types of risk reduction measures currently in place to address chemical and Natech accident risks (hazard mapping, scenario development, good practices, etc.). Example questions for Part IV (binary and open ended items) are shown in Fig. 6.

Finally, *Part V - Needs and Limitations* gives countries an opportunity to evaluate the country's current situation in regard to managing chemical and Natech accident risks, identifying strengths and weaknesses and priorities for the future. Example questions for Part V (5-point Likert scale items) are shown in Fig. 7.


11. Is there a requirement under existing Law to address chemical safety during inspections?

[ ] YES [ ] NO

If yes, please describe the type of training in chemical safety received by Inspectors:

Comments:

12. To the best of your knowledge, has the Country's approach to chemical accident prevention (including Natech) been effective in preventing major chemical accidents? *Please, indicate the level of effectiveness by marking a box below* (1-low or not effective, and 5, high effectiveness)

(LOW) 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] (HIGH)

Please provide some evidence/examples to support your choice above.

Fig. 4. Example of items in Part II (ENPI Survey).

3.1.2. Data collection process

Respondents were also sampled and selected as *national focal points* of reference per each country for data gathering and delivery (see Annex 1). Generally, two main focal points were available per nation. In this sense, due to the technical and regulatory complexity about the various sections of the survey, such focal points were encouraged to collect information across various data sources at regional or national level (e.g., dedicated ministries, those with relevant databases, multi-disciplinary task groups with dedicated data and operational knowledge, etc.). This delivery process was critical to obtaining responses that were as reliable and complete as possible. For several questions, it is clear that the sensitive nature of certain data and the diverse roles of different government authorities required, as much as possible, a process that produced a shared but also inclusive response.

3.1.3. Data collection results

A total of 10 out of 14 countries initially responded to the survey, consisting of Algeria, Armenia, Belarus, Georgia, Israel, Jordan, Moldova, Palestine, Tunisia and Ukraine (an 11th country, Lebanon, also responded after all replies had already been analysed). All countries fully completed each survey, with the exception of a few questions for individual countries, and in many cases they provided detailed explanations of their partial responses when requested. The full statistical results of the survey will be presented elsewhere (forthcoming paper), but this paper instead provides the overview of key results firstly in qualitative and secondly quantitative terms as well.

Based on the responses, it appeared that many countries had indeed consulted or had already knowledge of the activities of other ministries and sometimes local governments, while other responses had more limited input. The breadth of response is in fact evidence of a favourable or less favourable disposition towards building capacity in chemical accident risk governance. Experience within many EU and OECD countries has shown that, as a country's knowledge of about its chemical and Natech risks increases, the multidisciplinary nature of governance efforts, particularly the cross-government sharing of responsibilities, also increases. In other words, with more knowledge and experience, it becomes more and more obvious that effective risk management requires all of the authorities for the environment, civil protection, labour, and sometimes economy or interior, etc., to play a role and work together along with their technical units (e.g., inspectorates, research institutes) and their regional and local counterparts.

3.2. Qualitative data evidence

Qualitative analysis via open ended questions helped provide a descriptive "profile of the CAPP national situation" relative to the various first four sections of the ENPI Survey. The fifth section (Part V - Need and Limitations) is presented in the quantitative Section 3.3. A rich individual result and two cross-country results are now described, respectively, as qualitative data evidence.

3.2.1. Individual country level

Broad cross-sectional and highly informative data is reported in Table 1 for a single country. This shows the complex framework of response fields per country. For instance, the number and type of legal instruments for accident prevention, authorities enforcing national audits and inspected topics, data collection strategies for major events, estimates on common hazardous industries in the country, as well as national communication strategies with high hazard industries is investigated for each one of the participating countries. The identity of the Country in Table 1 is not revealed due to GDPR policy compliance [12] and simply termed Country "1" in this reporting. In addition, the letter "x" is used in place of numbers or words that could reveal the country's identity.

Notably, Country 1 depicted in Table 1 has both positive and negative indications in regard to alignment with the principles of the Seveso III Directive, that is, a comprehensive chemical accident prevention and preparedness programme. For example, the use of multiple risk analysis approaches indicates some competence in a key discipline for managing chemical accident risk. On the other hand, the country does not appear to have a formal definition of a major chemical accident. While there is an indication of some requirements, e.g., inspections, associated with processing and handling of dangerous substances, the enforcement documentation and instruments are still not fully developed.

Also the replies in Table 1 on risk reduction give both positive and negative signals regarding the strength of regulatory requirements. On the one hand, the requirement for sites to have a hazard and consequence analysis is significant, and indicates that the country has already given importance to a critical requirement of CAPP programmes. On the other hand, the remaining indicated risk reduction measures are limited. For example, there is no reference to safety management systems or land-use planning, suggesting that the existence of the hazard and consequence analysis supports emergency planning only. It seems that it does not necessarily trigger a legal obligation for the site or the authorities to take appropriate prevention and mitigation measures to reduce the risk that the emergency occurs.

3.2.2. Cross country level

A highly interesting result is given for survey responses to Item/Question 1 on the existence of a definition for "major chemical


20. How many chemical accidents (including Natech) were reported to the Government (if any) in the last 10 years?

[ ] 0 [ ] 1 - 5 [ ] 5 - 10 [ ] 10 - 20 [ ] > 20 [ ] Do Not Know

Fig. 5. Example of items in Part III (ENPI Survey).

43. Has the Country developed risk maps for natural hazards and chemical hazards (including Natech) for some or all parts of its territory?

[ ] YES [ ] NO

If Yes, please tell us for which regions for natural hazard(s):

44. Has your Country developed scenarios for chemical accidents (including Natech)?

[ ] YES [ ] NO [ ] NOT SURE

If Yes, please describe these chemical accident scenarios or one of the worst-case scenarios:

Fig. 6. Example of items in Part IV (ENPI Survey).

accident". In particular, three countries only have such a formal definition. None of these definitions is specific enough to determine the entity of damage, or specific causal factors of release. This is shown in Table 2. According to this very basic aspect, differences can emerge in accident models, and prevention and mitigation programmes due to the different definitions at national level.

In particular, Table 2 pictures clearly a lack of standards in definitions between the EU neighbourhood countries. In fact, even simple different definitions, or a lack thereof, can highlight different models underlying then different strategies to account for accident prevention and preparedness not always in the same positive developmental trajectory.

Furthermore, Table 3 reports for all ten countries some qualitative responses about gaps or shortcomings on national rules and regulations on chemical accident prevention topics. Such open-ended responses addressed Item 14 of the ENPI Survey (see Annex 1). Again this table depicts a highly differentiated set of national issues that may range from technical limitations in software capability to risk assessment methods (e.g., Country 2) to gaps in Legislative frameworks for chemical accident prevention and preparedness (e.g., Country 8).

It is important to note that the highly rich and semi-structured knowledge covered in the preceding Tables 1–3 allows exploratory judgements that might call for further investigation within and between countries. Such further investigations are now possible to conduct given the ENPI survey's low-level analysis.

3.3. Quantitative data evidence

Together with the qualitative portion of the ENPI survey covering all first four parts, the final Part V of the survey addressed country limitations, needs and resilience in CAPP programmes by application of dedicated quantitative analyses (ordinal/interval data measures) [14]. Composite measures, namely the *Limiting Factors Index*, *Capacity Building Needs* and *CAPP Capacity Robustness Indices* were generated by sub-setting non-weighted linear combinations of individual items selected from Part V of the Survey. This process reflects simple structure, face validity and simple interpretability. The structure of each index and its constituting items are reported in Table 4.

Methodologically, it was decided to follow first a face validity approach and a theory-driven definition of such composite indicators. A true factorial composition (via Principal Component Analysis) and statistical internal consistency of the measures (e.g., Cronbach's alfa) will be conducted in dedicated future research initiatives. A primary interest here was first to achieve face validity of the measures as derived by theoretical and expert judgment from previous research at this level of investigation.

3.3.1. Limiting Factors Index

The Limiting Factors Index is a measure of the degree to which various national conditions in the country may limit the ability to introduce CAPP programmes in national strategic planning. Item 49 of the ENPI Survey defines a non-weighted averaged linear combination of eight sub-questions testing, for instance, for undesirable "*Lack of knowledge (item 49b)*", "*Responsibility not defined (item 49 g)*" or "*Lack of adequately trained personnel (item 49c)*" affecting capacity building success in different ways (all sub-questions are described in Annex 1, Item 49).

The results and descriptive benchmark across countries for the Index is shown in Fig. 8. A rating on a 5-point Likert scale was applied with lower values mirroring favourable small limitations overall (from 1 = low limitation to 5 = high limitation). It was normatively defined that any index score above a mid-point score of 3 reflects a negative condition. Note that the selection of a normative criterion of splitting positive and negative responses is theoretical and should be considered for descriptive purposes only at this stage of research.

According to Fig. 8, the countries with the most serious limiting factors score (above 3) are Countries 1, 2, 3, 4 and 5. Instead, Countries 6, 7, 8 and 9 are potentially less limited with scores nicely below the normative reference of 3. (One country did not provide enough data to compute a score and it was dropped from the analysis.) Moreover, no specific regional trend (i.e., East vs. South) was visible. However, inspection of the most negative sub-questions common to all countries revealed that "*Responsibility not defined (item 49 g)*" and "*Liability and/or legal issues (item 49 h)*" are the largest limiting factors for promoting legislation aligned with the Seveso Directive.

Overall, this index could prove useful to track a country's progress over time, as well as to perform exploratory cross-country benchmarks.

3.3.2. Capacity Building Needs Index

The Capacity Building Needs Index estimates the needs related to core capacities to run a country-wise CAPP programme effectively. Item 50 of the ENPI Survey computes a non-weighted averaged linear combination of seven sub-questions representing specific competencies, resources and enforcement to grant capacity building success. For instance, the national focal points rated the need about further "*Training of officials in charge of chemical-accident prevention (Item 50a)*", or "*A complete inventory of significant chemical hazard sites (Item 50d)*". (All sub-questions are described in Annex 1, Item 50).

48. Please answer the items below by writing in the box at the end of each item the letter that best reflects your opinion.

	A Disagree Strongly	B Disagree Slightly	C Neutral	D Agree Slightly	E Agree Strongly	
a)	In the Country, risk managers/safety professionals in industry are aware of the concept of chemical accident events.					
b)	In the Country, chemical accident risks are discussed in the relevant Ministries.					
c)	Natech risks are discussed among those in charge of chemical disaster management in the Country.					
d)	There is enough emphasis on risk reduction for chemical accidents in the laws and regulations for chemical accident prevention and mitigation					

Fig. 7. Example of items in Part V (ENPI Survey).

Table 1
Qualitative descriptive statistics for Country 1 (Item sets from Section I to IV - ENPI Survey).

I. Legislation and regulatory context	
Selected items from ENPI survey	**Response**
Formal definition of major chemical accident (Item 1)	NO General definition: The term" major risk "is defined in Law xxxx-xx of December 20, 200 × : any probable threat to man and his environment that may occur due to exceptional natural hazards and / or because of human activities"
Legal instruments for CAPP (Item 4)	11 Instruments Some instruments: Exceutive decree nxxxx-… Executive decree nxxxx-… First in effect from 2003
Adoption of SEVESO/ COMAH/Installations Classées (Item 3)	NOT ADOPTED
Authorities with responsibility on CAPP topics (Item 5, 10, 23, 30, 49)	Ministry of Civil Protection Minister of the Environment Ministry of Energy Ministry of Industry
International conventions / activities (Item 8 A, 8B)	Convention No. 155 concerning Occupational Safety and Health and the Working Environment (1981) International Labour Organization (ILO)] United Nations Environment Programme (UNEP) The Flexible Framework for Chemical Accident Prevention and Preparedness.
II. Enforcement	
Requirement in inspections by law (Item 10 and 11)	NO
Authority for inspections (Item 10)	Ministry of Civil Protection Minister of the Environment Ministry of Energy Ministry of Industry
Inspected topics (Item 10)	Production, storage, transport & handling of chemicals, labour safety, licensing of industry, explosive and accident prevention for the work environment
Authority conflicts in CAPP enforcement (Item 14, 49, 50, 51, 52, 53)	The enforcement documentation and instruments are under processing (conflict may raise in this sense)
III. Accident awareness and competence in chemical accident prevention	
N° of major chemical accidents in the last 10 years (Item 18 A)	3
Authority collecting information on chemical accidents (Item 23)	The provincial office x in charge of the industry affected
Estimated number of hazardous sites (Item 25)	Not given
Most common hazardous industries of the country (Item 25)	Petrochemical
Substances of high concern (Item 27)	Not given
Industrial parks, ports and petroleum refineries (Item 28)	x industrial parks x major ports x petroleum refineries
Authority collecting information on hazardous establishments (Item 29, 30)	Ministry of Civil Protection Minister of the Environment Ministry of Energy Ministry of Industry
Government communication with industry (Item 32)	Scheduled formal meetings/ workshops
Main CAPP competence (Item 37, 38)	Internal: Rely on professional experts (external) External: Services for special expertise or major accident support
Government risk analysis approaches (Item 39)	Multiple methods reported Risk Matrix methods, Bow-Tie applications, Effects/PHAST/ALOA software
IV. Risk reduction measures	
Formal risk reduction measures adopted in country (Item 43, 44, 45, 46)	Impact and hazard analysis, internal emergency management plans, and intervention
Research activities/projects on chemical accident risk (Item 47)	NO

A 5-point Likert scale from 1 to 5 was applied: the higher the score, the stronger the need for a factor, thus a non-favourable condition. The point score of 3 was kept as normative cut-off reference again. So the criterion of splitting positive and negative responses is theoretical and should be considered for descriptive purposes only at this stage of research.

The results across all ten countries for the Capacity Building Needs Index is shown in Fig. 9. Apparently all of them require moderate to substantial support in strengthening capacity building independent of regional differences.

Three out of ten countries (Countries 1, 2 and 3) exhibit very negative gaps with scores from 4,42 to 5. On the other hand, Countries 9 and 10 have the most positive scores (3,57 and 3,14 respectively), but are still above the value of 3, indicating gaps to close for CAPP capacity building support.

3.3.3. CAPP Capacity Robustness Index

This third and final index is a measure of the resilience of the existing overall capacity in the country to implement an effective CAPP programme. The CAPP Capacity Robustness Index is based on six main dimensions as defined by previous research in capacity building studies [22] and described by the six nodes in Fig. 1 above. The new composite index mirrors the needs of *having the necessary resources*, reliable *relations between stakeholders and shareholders* (e.g., industries and local communities), key *integration of people and processes*, *levels of operational capability*, *delivery processes* and finally *effective legal frameworks* compliant with international laws.

In particular, each dimension was mapped with specific subsets of questions throughout the Seveso ENPI survey. The linear non-weighted combination of such individual scores for each of the 6 dimensions was averaged to create a measure for the global CAPP Capacity Index. The key items for the relative dimensions are fully described in Annex 2.

Cross-country results on the CAPP Capacity Robustness Index are shown in Fig. 10 for each of the ten European Neighbourhood Countries which participated in the survey.

The CAPP Capacity Robustness Index itself is scored, like the others measures above, along a 5-point scale with 1 = poor capacity and 5 = strong capacity. Higher scores (between 4 and 5) suggest a positive available capacity critical to Capacity Building success. Again, as a norm based on face validity of the items, any score below the mid-point scale of 3 is accounted for by a reduced level of capacity for CAPP programme implementation. Note that this score is reversed for positive ratings with respect to the previous two indices.

Table 2
Definition of a "Major Chemical Accident" – Summary of replies to Item 1 of the ENPI Survey.

Country ID[a]	Formal definition	Definition description
Country 1	YES	The term "major risk" is defined in the 2004–20 Law of December xx, 200 × : Any likely threat to humans and the environment that may occur due to exceptional natural hazards and / or due to human activities.
Country 2	NO	not reported
Country 3	YES	Chemical accident - an accident on chemically hazardous objects, accompanied by spillage or release of hazardous chemicals that can cause death or chemical contamination of people, food, food raw materials and feed farm animals and plants, or chemical contamination of the environment. (GXXX 22.0.05-XX, Safety in emergencies. Man-made emergencies.
Country 4	NO	n/a
Country 5	NO	There is no formal definition of a major chemical accident, but there are two definitions that replace it: 1) HAZMAT Accident (Hazardous Materials Low) – uncontrolled occurrence or accident which involves hazardous material and causes (or may cause) risk to people's lives or to environment, including spill, leak, dispersion, explosion, evaporation and fire; 2) Mass Disaster Accident (Police Ordinance) – accident, which causes severe damage to public safety, to people life and property and affects large public or large area. Mass Disaster Accident may be caused by HAZMAT Accident and in this case, the combined definition is a good alternative for what is called Major Chemical Accident.
Country 6	NO	No formal definition. Only a generic statement: It's an accident, including chemical hazard for the human, animals and environment
Country 7	NO	There is general definition in the law: the catastrophe with techno-genic character - spontaneous explosion and / or emissions of hazardous substances and poisoning, contamination with such substances; harmful substance - any substance coming into contact with living organisms, can cause harm;
Country 8	NO	We have laws concerning about chemical accident, but not have a formal definition for a major chemical accident, for example; law No.(X) for the year 199X concerning the environment, in this, chapter one in article one defines Environmental Disaster. (The accident resulting from natural factors or human act which caused severe damage to the environment and its confrontation requires potentials that may surpass the local capabilities). And law No. (x) for the year 200X concerning the civil defense. (two laws attached). Most national strategies are concerning about chemical accident, e.g. Environment Sector Strategy 201 × −202 × . (Attached)
Country 9	NO	n/a
Country 10	YES	Code of Civil Defense of X defines an "accident" - a dangerous man-made event that caused the damage, injury or population creates a separate territory or territories entity threat to life or health and leads to the destruction of buildings, equipment and vehicles means the breakdown of production or transportation process or causes excess, emergency emissions of pollutants and other harmful effects on the environment.

[a] Country numbering is random for GDPR compliance (Regulation (EU) 2016/679, 2018).

Overall Fig. 10 shows how only two countries out of ten provided a rather positive outlook with positive scores above 4. In particular, Countries 1 and 2 scored positively with 4,24 and 4,04, respectively, in regard to implementation capacity. Five countries instead were assessed rather negatively with Countries 6, 7, 8, 9 and 10 scoring below 3 overall. The overall outlook regarding CAPP robustness is not favourable, indicating substantial improvements would be required to bring the programme to EU or OECD-equivalent standards.

In general Fig. 10 clearly shows how the country profiles are differentiable and could potentially allow exploration of different capacity levels. This analysis could guide future country-specific interventions in order to prioritize and strengthen poor or inadequate CAPP functions. This analysis could be accompanied by a review of scores on the individual six finer grained dimensions composing the index (not discussed here) to determine where to target interventions.

3.4. General findings and recommendations

The results presented deal with findings in ten EU Neighbourhood countries, with some general exploratory focus on some individual nations. Note that cross-country descriptions have intrinsic added value over individual country results. Nevertheless, this high level description

Table 3
Gaps or Shortcomings in the Country's Rules or Codes in chemical and Natech accident risk reduction (ENPI Survey Item 14).

Country ID[a]	Response to ENPI Survey Item 14
Country 1	The implementing legislation for this aspect is not yet developed.
Country 2	Computer program [for] risk assessment and forecasting
Country 3	The legislation regarding the formation of the requirements of industrial safety (including in the industries listed in the survey) is positively balanced and based on national and international experience and meets the requirements for security and risk reduction occurrence of chemical accidents.
Country 4	n/a
Country 5	Some topics were detected as critical blocks in ability of ministries to reduce chemical accident risk and effect on population. The leading topics are: providing of hazardous risk information to public, training citizens in response to chemical accident, sharing and publicly displaying reports of accident investigation, inter-ministerial safety standards for industry, controlling transportation of dangerous goods.
Country 6	n/a
Country 7	Poor knowledge for effective chemical risk reduction
Country 8	• There are no rules or bylaws in X country concerning chemical accidents. • There is weak compliance with regulations. • The cooperation between ministries concerning chemical accidents is not clear and not efficient, as well as the overlapping between these ministries. • There should be a proper accident investigation committee to make recommendations for learning from previous accidents.
Country 9	We need to improve our regulation and control system and technical and organizational competence.
Country 10	1. Law of X of December 28, 2015 p. № 76-VII «On amendments and ceasing invalid legislative acts of X" determined a situation that makes it impossible for state supervision (control) of compliance with rules in the field of fire, technological safety and civil defence entities, including entities which operate chemically dangerous objects. 2. At this time in X there are no legislative requirements for the model structure and procedure of approval of plans for localization and liquidation of accidents (internal and external response plan). 3. It is necessary to amend the national legislation to adopt requirements of Directive Seveso-III, including: 1) bringing the terminology of legislative and other normative legal acts into conformity with EU law; 2) testing scientifically proven risk level of emergency on dangerous objects to determine the proper balance between the necessary measures to reduce such risk and insurance payments.

[a] Country numbering is random for GDPR compliance (Regulation (EU) 2016/679, 2018).

Table 4
Structure of Limiting Factors, Capacity Building Needs and CAPP Capacity Robustness Indices.

ENPI Index	ENPI Item reference (see Annex 1)	Sub-questions combination (see Annex 1)
Limiting Factor Index	Item 49	49a + 49b + 49c + 49d + 49e + 49f + 49 g + 49h
Capacity Building Needs Index	Item 50	50a + 50b + 50c + 50d + 50e + 50f + 50g
CAPP Capacity Robustness Index	Items 1 + 3 + 4 + 5 + 6 + 8 + 9 + 22 + 30 + 32 + 36 + 37 + 38 + 39 + 43 + 48 + 49 + 53	*Multiple sub-question combinations: see Annex 2*

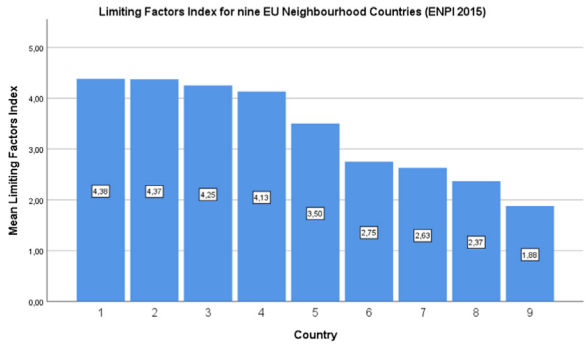


Fig. 8. Limiting Factors Index (ENPI Survey); Country identity retained for GDPR compliance (Regulation (EU) 2016/679, 2018)).

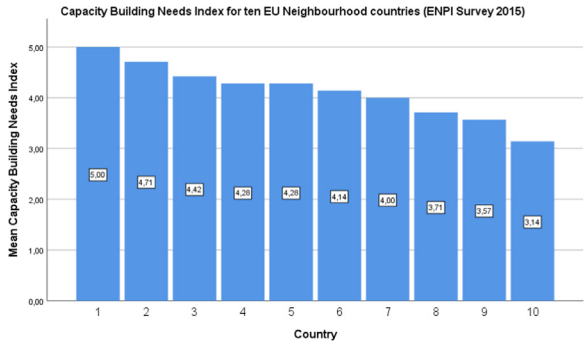


Fig. 9. Capacity Building Needs Index (ENPI Survey) country identity retained for GDPR compliance (Regulation (EU) 2016/679, 2018)).

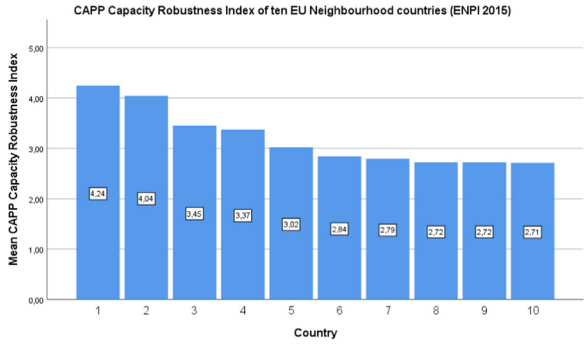


Fig. 10. CAPP Capacity Robustness Index (ENPI Survey) country identity retained for GDPR compliance (Regulation (EU) 2016/679, 2018).

without any country identity exposed is commanded by privacy and data security agreements for confidentiality and GDPR requirements today [12]. Also, the presented results are tentative as the ENPI survey is in its initial implementation and improvements are duly expected.

3.4.1. Findings of particular interest

Taking into account all countries analysed, some of the most interesting highlights are summarised below:

- **3 countries out of 10 have a formal definition of major chemical accident. None of these definitions is specific enough to determine the entity of damage, or specific causal factors**. Without formal and clear definitions the implementation and delivery of requirements is affected negatively (Item 1).
- **6 countries out of 10 have some requirements to address safety in inspections, while 4 do not have any. Training for inspectors on chemical accident prevention is noted as particularly poor in most countries** and requires a better strategy for the future (Item 10 and 11).
- **The majority of countries (9 out of 10) revealed gaps and shortcomings** in formal rules and codes for CAPP implementation/ regulation (item 14).
- **4 countries out of 10 provided information on establishment mapping** (nationally mapped). Two countries do not have mapping at all (Item 30, 43, 50 f)
- **3 countries out of 10 maintain regular and scheduled meetings with industry**. The lack of systematic communication between government and industry is a sign that the government is not in touch with industry. It may not be well informed about strengths and weaknesses in chemical risk management, including the level of competency and performance in regard to chemical process safety (Item 32).
- **Severe limiting factors for capacity building** are evident for 5 of the 10 countries in the sample (See Fig. 8)
- **All 10 countries** require moderate to substantial support in strengthening capacity building (see Fig. 9)

In the light of this evidence, and taking into account the complexity of the countries and regions involved in this survey, the suggestion for the future is to review needs and limitations case-by-case to target each country's specific limitations and needs.

3.4.2. Recommendations

Having a single standard strategy for capacity building initiatives may not be the most effective approach due to clear country differences and varied operational contexts. Also a further approach could be to explore with each country its formal understanding (legal) and tacit knowledge (actual knowledge level in government and industry) in regard to the definition of “major chemical accident”.

Inspection weaknesses and gaps, particularly training and access to guidelines and other reference materials, may be an area targeted for technical support in some countries. Overall, a follow-up dialogue with each country should further explore:

- progress in developing a comprehensive CAPP strategy, the current focus and level of detail
- specific gaps and limitations in the legal and regulatory framework
- type of major chemical and Natech accidents that have occurred in each country, particularly for countries which did not provide complete descriptions (if at all)
- kind of lessons learned from past chemical accidents if any and if not, why not

- extent to which hazardous site maps cover all major hazards and level of detail (e.g., types of industry sectors, substances, risk contours, etc.)
- additional types of risk reduction measures that are being imposed beyond the examples given in the surveys

Mapping hazardous establishments and more robust communication with industry may be necessary in future strategy to strengthen CAPP capacity in many countries.

4. Discussion and conclusions

The Seveso ENPI Survey was conducted across a sample of 10 EU Neighbourhood Countries on the current status of their Chemical Accident Prevention and Preparedness (CAPP) programmes in comparison with the Seveso Directive and their exposure to chemical accident risks. The present survey actions stemmed from the DG-ECHO and Joint Research Centre collaboration to support capacity building for implementation of the Seveso Directive requirements in European Neighbourhood Policy Countries within the framework of the European Union Civil Protection Mechanism 2014–2020.

The purpose of the Seveso ENPI Survey was to obtain relevant and reliable country profiles, strengths and weaknesses of countries' CAPP programmes and their capacity to implement a programme effectively to address specific chemical accident risks (either man-made or Natech type accidents)

The results will be used by the European Commission to:

i) identify priority topics for the development of analytical and infrastructure tools and for training and technical assistance exercises and,

ii) as a basis for dialogue with each country to explore opportunities for bilateral collaboration.

Trends in capacity building and estimates by repeated survey samplings could be modelled in the mid-term future over the same ten EU Neighbourhood Countries accordingly. This tracking would allow measurement of trends over a certain period, such as every two or three years. In particular, this could be achieved in the future by identifying selected *leading indicators* (primarily from the presented indices) that can be measured over time to detect progress in achieving capacity building objectives.

The Limiting Factors Index, the Capacity Needs Index, and the CAPP Capacity Robustness Index could then be applied over targeted samples of further selected European Neighbourhood Countries to estimate the success rate of capacity building for single or grouped European Neighbourhood Countries and/or for regional blocks. In the future, a statistical approach could potentially allow a sensitivity analysis around certain parameters, identifying key areas where improvements could substantially accelerate capacity building progress. Put simply, the use of the results on the CAPP Capacity Robustness Index could suggest the type and extent of changes needed to improving capacity building success rates in the future.

Some next steps in the evolution of the indices have also been proposed. In discussion of project results with countries and internal European Commission stakeholders, the idea arose that an additional index that measures alignment of government programmes with the core Seveso Directive elements, derived from the survey data, would be useful. Overall, the three indices produced in this study measure government capacity on the basis of the collective resources and mechanisms in place to support CAPP strategy. Conversely, a Seveso-specific index would evaluate the degree to which specific core elements of CAPP programmes as embodied in the Seveso Directive were already in place. This index would be particularly powerful in communicating in a policy context progress in terms of alignment with the EU Seveso Directive.

In addition, the CAPP capacity building methodology could obtain critical leverage in international policy-making in regard to global CAPP capacity building strategy. As such, further testing the application of the indices outside the EU Neighbourhood Countries would be a desirable follow-up at some stage. The methodology could be applied, for example, in EU Enlargement countries or even in third countries as the opportunity arises. It has also been proposed that the methodology could be transformed into an online application to allow its use by other similar EU or international projects, or as a self-assessment tool for countries themselves.

Acknowledgements

The authors thank the countries who responded to the survey on which this study is based, and Mark Hailwood of LUBW and Johanna Suikkanen, then of UN Environment, for their contribution to the development of the survey. We are also grateful to Roberto Schiliro of the European Commission's Directorate General for European Civil Protection and Humanitarian Aid Operations for his unfaltering support.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ijdrr.2018.07.023.

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