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People-centered early warning systems in China: A bibliometric analysis of policy documents

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ABSTRACT

People-Centered Early Warning Systems (PCEWSs) is thought to be low-cost but effective, however, existing studies fail to discuss the basic characteristics of PCEWSs, how a PCEWSs should be built, and the extensible applications of PCEWSs. This study aims for making a significant contribution to the literature through the analysis of the PCEWSs trajectory of and fundamental shifts in policy pertaining to PCEWSs in the disaster domain in China. By using bibliometric analysis of policy documents, this study presents a comprehensive review of China's PCEWS policy system from 1977 to March 2020, which focuses on various types of disasters. The characteristics of policies and the contributing factors of the policy changes in each of the four phases are discussed in depth. Four main tendencies of PCEWSs are identified. This study provides a quantitative foundation for understanding the dynamic policy changes in China's PCEWSs and certain experience includes the disaster characteristics that PCEWSs are suitable to get involved, the orientation that experience and technology should be combined and multi agent participation which calls for more emphasis may serve as a basis for exploring the potential pathways to the effective PCWSs in other countries and regions.

1. Introduction

The costs and impacts of natural disasters on people, property, and the environment are often severe when natural disasters occur on a large scale and with no warning and monitoring system in place. Better Preparedness and awareness may save lives and in a very inexpensive manner [1,2], which will be strengthened by waring and monitoring mechanism. According to the United Nations International Strategy for Disaster Reduction (UN ISDR), there are basically two principles for effective EWSs: having strong technical foundations and good knowledge of risks and being people-centered [3]. Scholars usually focus on the technology and engineering of EWSs, for example, the design and implementation of a landslide EWS [4] and modern information technology applications for mountain flood disaster monitoring and early warning [5]. However, we cannot apply all high-tech products to all-phase, all-hazard and all-stakeholder (the three major dimensions of comprehensive emergency management, which is an idea widely embedded in the emergency management systems of various countries) emergency management because of economic and technological limitations. Notably, in developing countries such as Indonesia and Nepal, where the central governments cannot afford the high cost of positive mitigation activities, it is difficult to determine the most vulnerable groups from official forecasts.

So, is there any low-cost but effective EWS? Some studies have concluded that a people-centered approach is the best approach for an effective early warning system [6]. UN ISDR(2005) survey report also suggested that no matter the hazard it addresses, an effective EWS must be people-centered [7]. PCEWSs first gained major attention after the Indian Ocean tsunami on 26 December 2004, UN ISDR(2005,2006) strongly recommended to build a national PCEWSs [6,8], the Sendai framework acknowledges the need for the participation of citizens and nonprofessionals when dealing with multiple hazards [9]. Putting people first is the key message of the "first mile" approach [10], which means that the system places the affected people at center stage and

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recognizes their role in reducing their vulnerability to the hazards they face. It is meaningful to transfer responsibility to communities and to widely encourage citizens to participate in both disseminating and responding to disaster information in "at-risk" communities, as shown by the Hyogo Framework for Action [7]. This approach to disaster risk reduction (DRR) is meant to empower local people and is also intended to build local resilience to disasters, as communities are taught by facilitators from international nongovernmental organizations (INGOs) how to better help themselves manage local risks [11].

In practice, very successful PCEWSs have been developed in Asian countries, probably because natural disasters frequently affect these nations [12,13]. For example, the Japanese system couples monitoring and warning services with dissemination and communication [14]. The Chinese government has established EWSs that rely on citizens; such systems are called "mass monitoring and prevention" (MMP) (or "collective monitoring, collective defense") [15,16]. Ultimately, "collective monitoring, collective defense" programs depend, in principle, on a highly regimented society [15]. Such programs are programs of collective defense, not entirely different from those of the commune militia [15]. China proposed the concept as early as the 1960s [16]. Based on earthquake MMP, the success of the prediction of the Haicheng earthquake and the failure of the prediction of the Tangshan earthquake were both well publicized worldwide [17]. MMP initially focused on earthquakes, but it is currently applied in many fields, such as geological disasters and domestic security events.

Theoretically, PCEWSs have been widely developed in many kinds of disasters, such as, food crisis [18], landslide [19,20], tsunami [21,22], environmental protection [23,24], flood [25,26], fire safety [27,28], among others. There are basically four interrelated elements in PCEWSs: risk knowledge, monitoring, communication of warnings, and response capability [7]. People play a significant and transversal role in all steps [29,30]. Besides, form perspective of human factors, risk perception and communications [30] and response capability [27] are important in PCEWSs. However, both the UN ISDR and existing studies fail to discuss the basic characteristics of PCEWSs, how a PCEWSs should be built, and the extensible applications of PCEWSs [10,21,31,32]. Therefore, this study aims for making a significant contribution to the literature through the analysis of the PCEWSs trajectory of and fundamental shifts in policy pertaining to PCEWSs in the disaster domain in China. Hopefully, our findings can contribute to both the theoretical development and crisis governance in other countries.

2. Materials and methods

The policy document data were extracted from the PKULaw Database.[1] "Mass monitoring and prevention" (MMP - Quncequnfang), and "mass prevention and governance" (MPG - Qunfangqunzhi), referring to the participation of people in emergency management, were used as the keywords for the search in the database. Here, MMP and MPG are collectively referred to as PCEWSs in China. A total of 4055 policy documents at all administrative levels from 1977 to the present were retrieved, including 360 documents at the national governmental level (i.e., those by the Central Committee of the Communist Party of China (CPC), the State Council (SC) and its direct affiliates, national bureaus, national associations, and national offices directly under the Central Committee of the CPC) and 3931 documents at the local governmental level. Since national-level policies set the guidelines for local governments in China [33], we analyzed only the national-level policies. Each of the selected policy documents includes keywords, the policy-making departments, the level of authority, the regulatory category, the year, and the effectiveness status.

This study employed co-word analysis and cluster analysis (see Fig. 1), which are commonly used in mapping research topics or in tracing the evolution of policy [34–37]. As a vital method of bibliometric analysis, co-word analysis assumes that a policy text's keywords constitute an adequate description of its content [34]. In the co-word network, degree centrality measures the strength of the relationships among high-frequency keywords [36,38], and it is also used to reflect the size of every keyword, that is, the nodes. Moreover, the frequency of the simultaneous occurrence of one keyword and other keywords measures the clusters. As Carrington et al. mentioned, cluster analysis forms the most connected nodes into one group and removes nodes with few connections outside the subgroup [39]. Thus, keyword clusters of policy documents can be understood as a short description of policy priorities.

Specifically, word segmentation was preprocessed firstly. Screening thesaurus in ROSTCM6[2] was employed to eliminate meaningless words except for verbs and nouns. In order to further ensure the accuracy of word segmentation results, this study input the words of mass monitoring and prevention (MMP), mass prevention and governance (MPG), disasters and emergency events types and government agencies into the custom thesaurus. Secondly, word frequency statistics are carried out on the word segmentation data of each phrase and we selected the top 6 high-frequency keywords for each policy text on average to construct co-word matrices for each phase of policy development using ROSTCM6. Then, multidimensional scaling (MDS) was applied to lay out the co-word network using the "Net-Draw" function of UCINET 6.0,[3] and the "Factions" function was used to divide the whole network into certain clusters. Finally, certain network data were imported into VOSviewer[4] for visualization, and different clusters (subgroups) are marked with different colors or different dotted boxes. To further inspect the inter-departmental collaboration of policy-making departments in different periods, each department was taken as a vertex, and the collaboration of departments that jointly issued policies was taken as an edge to construct the network. Then, the cluster network was visualized by NodeXL.[5] The size of each node depends on its degree centrality, and the sequence of nodes was also ordered by their degree centrality.

3. Findings

Fig. 2 illustrates the annual number of PCEWS-related policies issued from 1977 to March 26, 2020, and there are three major peak years, including 1991, 2003 and 2011. Many studies have proved that most focusing events change the dominant issues on the agenda in a policy domain in the context of natural disasters and industrial accidents, they can lead to interest group mobilization, and groups often actively seek to expand or contain issues after a focusing event [40–43]. After combining the peak years and the history of China's disaster occurrence and response practice, we found that the whole PCEWSs policy development process also shows such characteristics.

In detail, the formal institutional design of PCEWS practice in China originated in 1977. From 1977 to 1991, the number of relevant policies released was small and remained steady. Around 1991, the activities of cults and thefts are frequent and Comprehensive Treatment of Social Management Committee was built as 5 pieces of related policy were issued in public security. From 1992 to 2003, and the PCEWSs applications were expanded. 2003 is such a demarcation point for central government to reflect on lessons learned and build a national emergency management system which involves PCWSs in the wake of SARS outbreak. It also explains that the 2003–2011 period was a period of sharp development in terms of the number of relevant policies. In 2011,

[1] PKULaw Database (http://www.pkulaw.cn) is the first and most influential Chinese legal document search system, recording all the policies, laws, and regulatory documents since 1949.

[2] A content digging system designed by a virtual learning team at Wuhan University, China.

[3] http://www.analytictech.com/products.htm.

[4] https://www.vosviewer.com/.

[5] https://archive.codeplex.com/?p=nodexl.

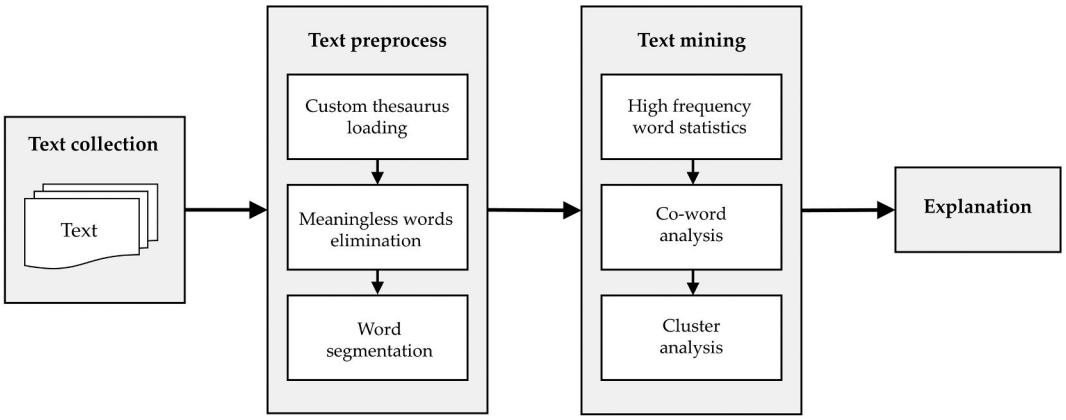

Fig. 1. Process of co-word and cluster analysis.

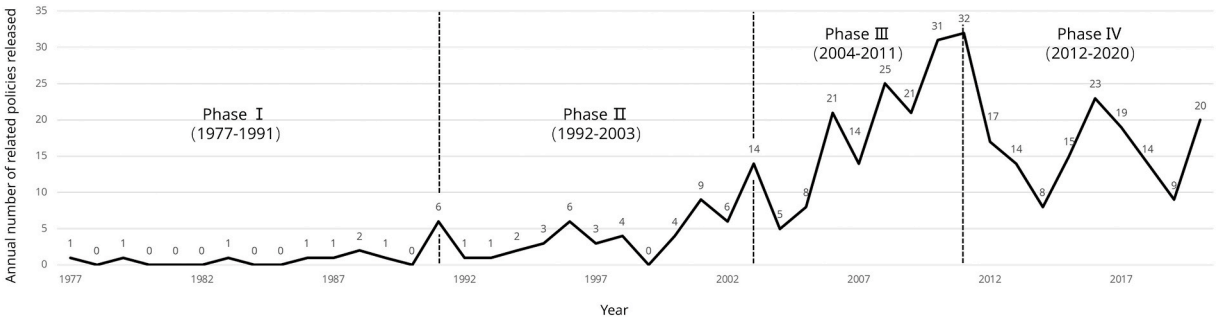

Fig. 2. Annual number of PCEWS-related policies released in China, 1977–2020.

freezing rain and snow disaster in western south China poses a great challenge to China's disaster management system, since this year, the number of policies has decreased, but the overall level remains relatively high and was accompanied by a certain degree of volatility. After the International Conference of Emergency Management (2012) held in Beijing, some opinions as "strengthen trans-regional, cross-sectoral emergency coordination linkage, all-weather emergency concept such as risk assessment and monitoring and early warning system"" got stressed so that PCEWS-related policies no longer take the form of areas or departments scattered, instead, more comprehensive to be displayed in single text. So, the development of China's PCEWS can be divided into four phases:

3.1. Phase I: early exploration (1977–1991)

Only 14 policies referring to PCEWSs were issued from 1977 to 1991. Fig. 3 shows that PCEWSs were applied to earthquakes (1977), endemic disease prevention (1986), mental health (1987), blindness prevention (1988), domestic security (1988), and schistosomiasis prevention (1991).

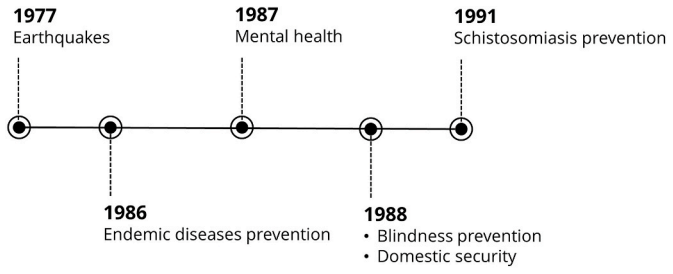

Fig. 3. Time of the first application of PCEWSs for various disasters (1977–1991).

The clustering network of policy keywords (Fig. 4) illustrates three subgroups of the main disaster distribution: schistosomiasis health, domestic security, and natural disasters. The scope of application of China's PCEWS practice for earthquake disasters originating in the field of natural disasters has been developed to a certain extent in the field of public health and, in particular, in the field of domestic security. Clearly, in this stage, PCEWSs focus on earthquake disasters, comprehensive governance and crime, and schistosomiasis prevention in the fields of natural disasters, domestic security, and public health events, respectively. In the field of domestic security, more than 890,000 cases were registered in 1981, of which 67,000 were major cases, according to the statistics of the Ministry of Public Security (MPS). In the field of public health, patriotic health campaigns against malaria and schistosomiasis are flourishing, and it is easy to see that PCEWSs have become an integral part of the emergency management practices in these fields.

Additionally, in the process of practice, the participation and cooperation of central government departments are shown in Fig. 5. In this phase, the number of PCEWS-related policies of the State Council (SC) is the highest. Regarding functional departments, the cooperation among the Ministry of Civil Affairs (MCA), Ministry of Public Health (MPH) and the Ministry of Public Security (MPS) is relatively close, and it is easy to see that administration subjects have a more interactive collaboration in the fields of public health and domestic security. In contrast, in the field of natural disasters, the state seismological bureau seems to be more directly involved with the central government and does not cooperate with other functional departments. To the end of this phase, PCEWS practice has been formally designed in the fields of natural disasters, public health and domestic security, but the work is still dominated by various functional departments.

3.2. Phase II: preliminary development (1992–2003)

There are 53 related policies in this stage, and PCEWSs were applied

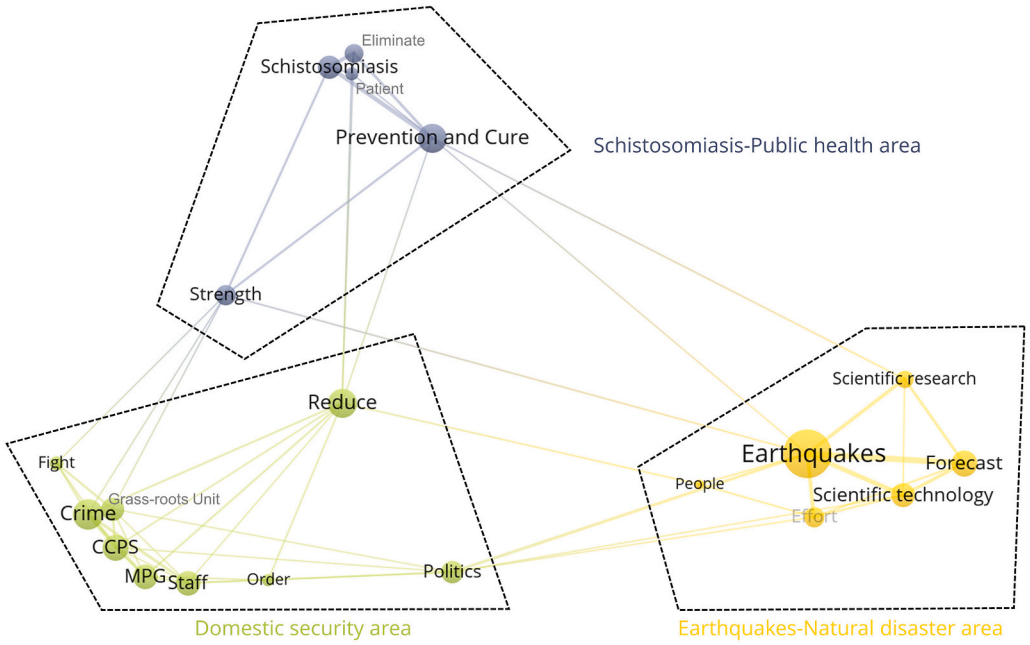

Fig. 4. Co-word analysis and cluster analysis of keywords (1977–1991).

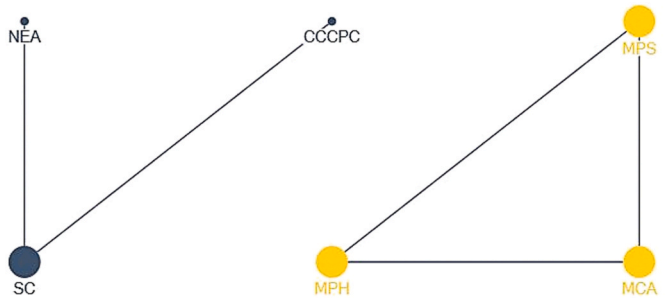

Fig. 5. Network of PCEWS policy-making departments (1977–1991), Acronym: National Earthquake Administration (It changed into CEA: China Earthquake Administration in 1998) (NEA), Sate Council (SC); Central Committee of the Communist Party of China(CCCPC), Ministry of Public Health (It changed into National Health Commission in 2013) (MPH), Ministry of Public Security (MPS), Ministry of Civil Affairs (MCA).

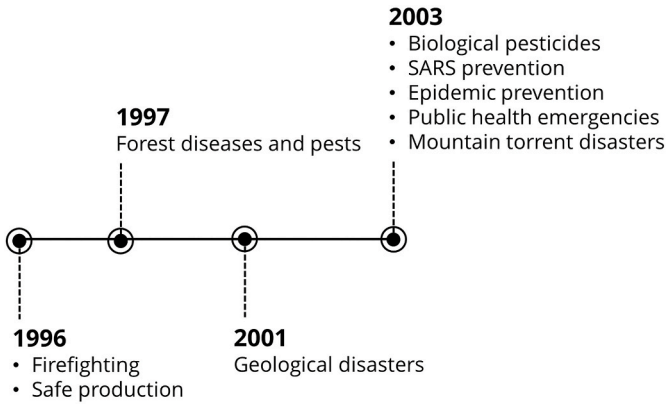

Fig. 6. Time of the first application of PCEWSs for various disasters (1992–2003).

to 9 disaster areas for the first time, including firefighting (1996), safe production (1996), forest diseases and pests (1997), geological disasters (2001), biological pesticides (2003), severe acute respiratory syndrome (SARS) prevention (2003), epidemic prevention (2003), public health emergencies (2003), and mountain torrent disasters (2003)(see Fig. 6). Compared to the first phase, the number of policies for all disasters or fields involved in PCEWSs increased, especially in the field of domestic security, where the number of relevant policies accounted for 58.5% of the total number of policies in this phase. Notably, after 1992, there were MMP policies focusing on domestic security every year except 1999. Additionally, a PCEWS was applied in the field of accident calamities, which includes engineering and safe production, for the first time. In 1996, as a result of the "Ten-year development plan of railway fire protection" and "The coal law of the People's Republic of China", PCEWSs were formally applied to the field of accident calamities and safe production. In 2003, 14 policy documents related to PCEWSs at the national level were issued, including in the fields of natural disasters, public health, and domestic security. Accordingly, PCEWS practice has developed to a large extent.

The co-word analysis and cluster network show four subgroups, mainly focusing on social order and campus safety management, production safety accidents and geological disasters (see Fig. 7). Domestic security became the structural focus of PCEWSs in this phase for two clusters. Compared with the first phase, in the second phase, importance is attached to the application of PCEWSs for safe production and accident calamities, which involve building engineering, construction and other areas. In particular, industry construction policies are gradually highlighted in the keyword clusters, reflecting the PCEWS application areas and the structural migration that occurred by degrees. At the same time, since PCEWSs were first used in the field of geological disaster prevention and control in 2001, the policy keywords related to natural disasters chiefly focus on "geological disasters", "territorial resources", "ecological environmental protection", and "forest diseases and insect pests", reflecting the priorities of PCEWSs utilization in regard to natural disasters in this phase.

The collaborative network between central government departments in this stage is shown in Fig. 8. Compared with the first phase, the number of national-level relevant policy-making subjects involved in PCEWSs is much higher. In all clusters, in this stage, the Central Committee of the Communist Youth League (CCCYL), All-China Women's Federation (ACWF), Ministry of Public Security (MPS) and Ministry of Civil Affairs (MCA) have increasingly close ties with the functional

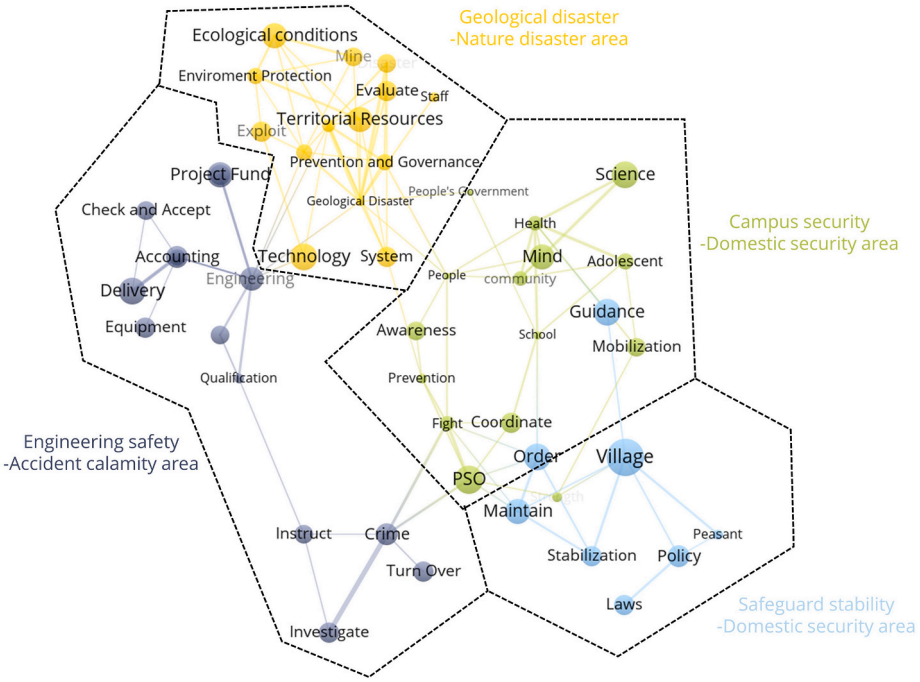

Fig. 7. Co-word analysis and cluster analysis of keywords (1992–2003).

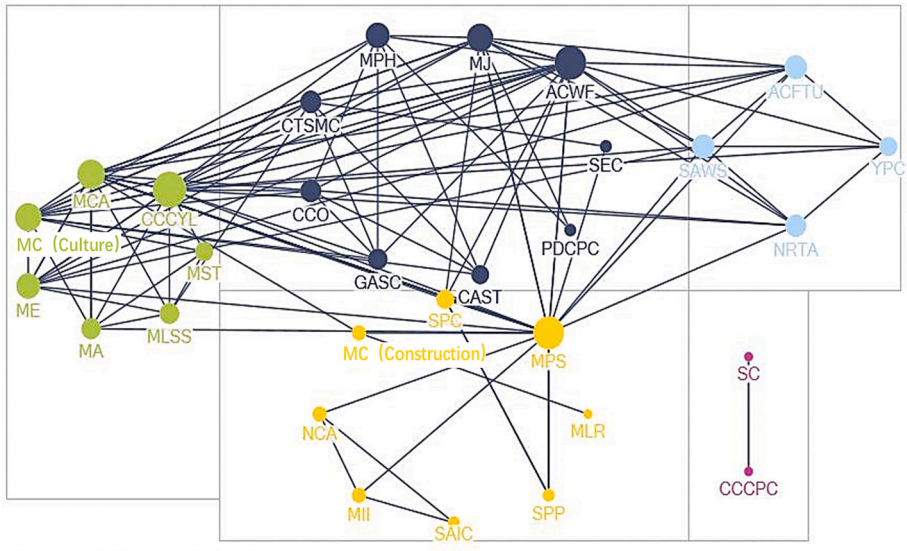

Fig. 8. Network of PCEWS policy-making departments (1992–2003), Acronym: PDCPC: Publicity Department of the Communist Party of China, MJ: Ministry of Justice, MPH: Ministry of Public Health (It changed into National Health Commission in 2013), SEC: State Education Commission (It changed into Ministry of Education in 1998), CTSMC: Comprehensive Treatment of Social Management Committee (It dissolved in 2018), ACWF: All-China Women's Federation, GASC: General Administration of Sport of China, CAST: China Association for Science and Technology, CCO: Centre Civilization Office, MC(Construction): Ministry of Construction (It changed into Ministry of Housing and Urban-Rural Development in 2008), MLR: Ministry of Land and Resources, MPS: Ministry of Public Security, SAIC: State Administration for Industry and Commerce (It dissolved in 2018), NCA: National Copyright Administration, MII: Ministry of Information Industry, SPP: Supreme People's Procuratorate, SPC: Supreme People's Court, MCA: Ministry of Civil Affairs, MLSS: Ministry of Labor and Domestic security (It changed into Ministry of Human Resources and Domestic security in 2008), CCCYL: Central Committee of the Communist Young League, MC (Culture): Ministry of Culture (It changed into Ministry of Culture and Tourism in 2018), ME: Ministry of Education, MST: Ministry of Science and Technology, MA: Ministry of Agriculture (It changed into Ministry of Agriculture and Rural Affairs in 2018), SAWS: State Administration of Work Safety (It dissolved in 2018), ACFTU: All-China Federation of Trade Unions, NRTA: National Radio and Television Administration, YPC: Young Pioneers of China, CCCPC: Central Committee of the Communist Party of China, SC: Sate Council.

departments in various fields of education, science, culture and health. The applications of PCEWSs in different fields involve many subdivisions of life and production. In this phase, PCEWSs widely mobilize the participation of people in various occupational and industrial fields.

3.3. Phase III: rapid development (2004–2011)

In this phase, PCEWSs were widely used, with 157 policy documents, accounting for 43.2% of all policy documents over the entire study period. This period is a period of very rapid development for the institutional design and practice of PCEWSs by Chinese authorities. In this phase, PCEWSs were applied for the first time in a total of 20 disaster areas (see Fig. 9). Notably, after the SARS outbreak in 2003, the absolute number of PCEWS-related policies for public health events was not large because the policy response had already gone beyond the limitation of a single disaster and PCEWSs had been applied in the context of a comprehensive response to public health emergencies. At the same time, in addition to the main areas of natural disasters, accident calamities, public health and domestic security, there is also one policy document in the fields of labor protection, force construction, public transportation, etc., which reflects the wide application of PCEWSs and the high degree of governmental attention.

The results of the co-word analysis and cluster network can be divided into three main subgroups (see Fig. 10). The subgroup borders no longer appear in a very clear field of disaster areas, but the higher number of clusters of organizations and participation subjects highlights the changes from the first and second phases. All the clusters should include the emergency center of multiple disaster areas, subjects of national legislation and community participation. After construction of the "One-Plan-Three-System [44]", the important position of "emergency" in policy documents continuously emerged. Epidemic-related keywords and geological disasters, flood control and drought relief, weather and other natural disaster subgroups show the way in which "emergency" has been extended through differentiation; therefore, the network shows that the structure of PCEWSs in emergency management in China has gradually developed into multi disaster linkages and then towards the leading position of central hubs and the application of various business department synergy patterns. At the same time, compared with the previous two stages, an increasing number of keywords, such as "community", "social organization", and "community service", have entered the vision of policy making, providing a more abundant and effective carrier for PCEWSs.

The cooperative network of policy-making departments in this phase is shown in Fig. 11 to support above result. Compared with the previous two stages, although a series of functional departments had a high level of degree centrality, increasingly more comprehensive management departments at the state level were involved, including the Comprehensive Treatment of Social Management Committee (CTSMC), Central Committee of the Communist Young League (CCCYL), Central Leading Group on Rural Work (CLGRW), Central Leading Group for Stability Maintenance (CLGSM), and Central Guidance Commission for Constructing Spiritual Civilization (CGCCSC), among others. Moreover, these state-level comprehensive management departments distributed all clusters in the network, and their collaboration with other functional departments was strengthened.

3.4. Phase IV: steady and deepening stage (2012–March 2020)

In this phase, there are 137 policies related to PCEWSs. In this phase, PCEWSs were applied for the first time to 15 disaster types or fields, showing the wide range of application (see Fig. 12). The overall distribution of disaster types is mainly concentrated in the fields of natural disasters, public health, domestic security and accident calamities. In 2015, PCEWSs were formally incorporated into the integrated management of the emergency system by a document titled "The letter of the general office secretariat of the State Council on printing the operation and management measures of the national emergency early warning information dissemination system (for trial)". As of March 13, 2020, it is observed that since the COVID-19 outbreak in early 2020, PCEWSs for public health events have been widely used in the field of public health governance, and the number of related policies has reached 20.

Interestingly, in Fig. 13, the PCEWS-related policies are highly influenced by the practice of epidemic prevention and control in regard to COVID-19, and keywords related to public health and epidemic prevention and control form a cluster subgroup. The significant difference from the three phases above is that the border among clusters has become blurred, which means that the co-occurrences of all the high-frequency keywords in this phase are high and similar. Simultaneously, "technology", "monitor" and "mechanism" have become the center of the network structure, which clearly indicates a development orientation of the PCEWS application mode.

Correspondingly, the relevant policy-making departments have also undergone structural changes, as shown in Fig. 14. In the departmental cooperation network, in addition to the vital role played by some comprehensive agencies at the national level, the technology-oriented development of PCEWSs was supported by a series of departments, such as the Ministry of Industry and Information Technology (MIIT), Ministry of Science and Technology (MST), National Copyright Administration (NCA) and National Intellectual Property Administration (NIPA), and these agencies are closely related to other functional departments in every subgroup. The appearance of these agencies and the cooperation structure responded to the results of policy priorities.

4. Discussion

Based on the policy statistics results above, this section explores and analyzes the characteristics and the PCEWSs trajectory of and

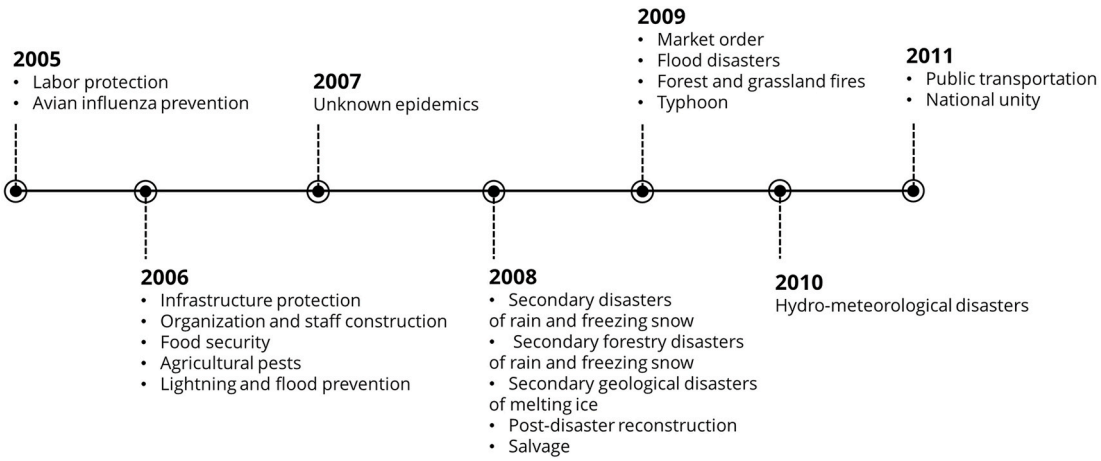

Fig. 9. Time of the first application of PCEWSs for various disasters (2004–2011).

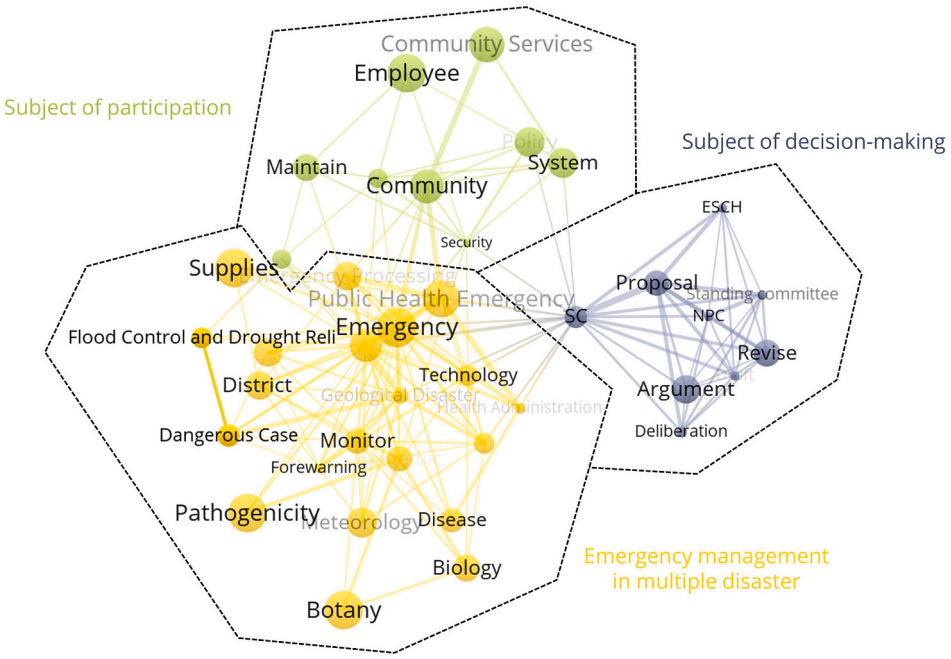

Fig. 10. Co-word analysis and cluster analysis of keywords (2004–2011).

fundamental shifts in policy pertaining to PCEWSs in the disaster domain in China.

4.1. The characteristics of disasters that PCEWSs have been used

PCEWSs have been widely used in more and more kinds of disaster management, which means they are effective and recognized by disaster managers. The application domains of PCEWSs, which exist as a subsystem, gradually move from diversification to disaster synthesis instead of separate execution (see Fig. 15). The most concentrated applications of PCEWSs are to geological disasters, engineering safety, community security and prevention, and infectious disease treatment. In this process, focusing events can drive governments to react to disasters [42], such as SARS, Wenchuan earthquake. From the perspective of the characteristics of disasters, PCEWSs are applied to nonsudden or chronic disasters. Different from emergencies resulting from sudden natural disasters, such disasters are commonly characterized as being chronic, being slow to appear and having certain precursors and potentials. One of the reasons is that chronic, latent disasters can be detected by community residents in time; that is, there is a time gap between the induction and the disaster, which makes it possible for the role of PCEWSs to be embedded. PCEWSs can make preparations in advance and implement relevant preventive measures based on the observation and signs of disasters.

Furthermore, PCEWSs have been used to the disaster association or the disaster synthesis formed by the disaster chain as well, and the role of PCEWSs is actually embedded in the dominoes and cascade effect of disasters. Based on the PCEWS-related policy development in the third phase, the same policy document simultaneously stresses the combination of disasters one after another, including mountain floods and geological disasters, sleet freezing and thawing secondary disasters, floods, geological, forest and grassland fires, earthquake and typhoon disasters, geological disasters crime and blasting mining accidents, and hydro-meteorological disasters.[6] Among them, hydro-meteorological disasters often become disaster-causing factors for various hydrological disasters like mountain torrent disasters, landslides and flooding and drought. Furthermore, mountain torrent disasters and geological disasters are interdependent and may have common inducing factors. Based on their characteristics, mountain flood disasters and geological disasters tend to display a periodic trait, making it possible to prepare in advance to implement the relevant personnel and material resources, naturally retaining space for the role of PCEWSs to make a difference.

4.2. From non-normalization to normalization in the "disaster management cycle"

From the perspective of the "disaster management cycle" (HYOGO framework), the role of PCEWSs is more or less functional at each stage of the disaster cycle, and the time point in which it is embedded has gradually moved from just the warning to the full cycle; furthermore, the PCEWSs become sustainable and normal application (see Fig. 16). Not only is the function of PCEWSs one of warning, but expansion has also been realized from early warning to regular monitoring and then to prevention and governance.

PCEWSs were first applied in the earthquake disaster field, mainly aimed at "mitigation and resilience" and "preparation and mobilization" in the beginning. Along with the deepening of practice, PCEWS-related policy for public security mentioned "joint strike, renovation" for the first time in the second phase of policy development, indicating the core tasks in the third stage of the disaster cycle. Then, PCEWSs were applied to public health events after 2003, which might because of SARS. In 2005, the Ministry of Agriculture proposed that social organizations, enterprises, public institutions, volunteers and other social forces should be mobilized to participate in emergency rescue work with regard to a sudden outbreak of the highly pathogenic avian influenza, aiming to strengthen the public response capacity in townships and communities.[7] "Recovery and Reconstruction" has become a focus area for PCEWS

[6] "Opinions of the General Office of the State Council on doing a good job during the National Day Holiday", 2009. http://www.gov.cn/xxgk/pub/govpublic/mrlm/200909/t20090929_33942.html.

[7] "The Notice that Ministry of Agriculture issued emergency implementation plan for prevention and control of highly pathogenic avian influenza in autumn and winter 2005", 2005.http://www.pkulaw.cn/fulltext_form.aspx?Gid=60644.

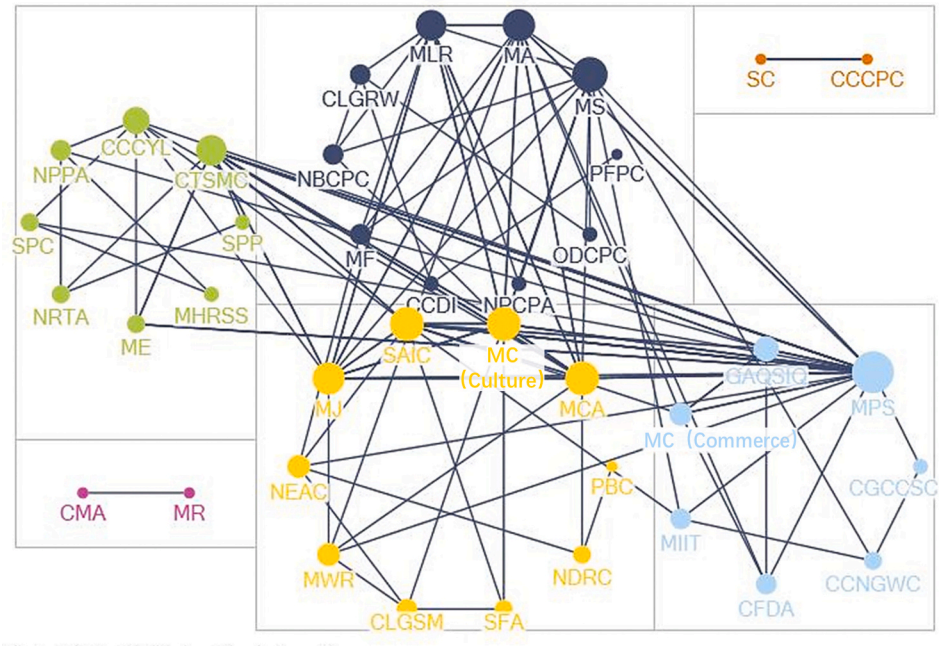

Fig. 11. Network of PCEWS policy-making departments (2004–2011), Acronym: State Administration for Industry and Commerce (It dissolved in 2018)(SAIC), State Forestry Administration (It dissolved in 2018)(SFA), Ministry of Culture (It changed into Ministry of Culture and Tourism in 2018)(MC), Central Leading Group for Stability Maintenance (It dissolved in 2018)(CLGSM), Ministry of Civil Affairs(MCA), Ministry of Justice (MJ), Ministry of Water Resources(MWR), National Ethnic Affairs Commission(NEAC), National Development and Reform Commission (NDRC), People's Bank of China(PBC), Central Commission for Discipline Inspection(CCDI), Central Leading Group for Rural Work(CLGRW), Population and Family Planning Commission (It dissolved in 2013)(PFPC), Ministry of Agriculture (It changed into Ministry of Agriculture and Rural Affairs in 2018)(MA), Ministry of Supervision (MS), Organization Department of the Communist Party of China(ODCPC), Ministry of Land and Resources(MLR), National Bureau of Corruption Prevention (It dissolved in 2018)(NBCP), Ministry of Finance(MF), National Public Complaints and Proposals Administration(NPCPA), Ministry of Human Resources and Domestic security (MHRSS), Supreme People's Court(SPC), National Press and Publication Administration (NPPA), Central Committee of the Communist Young League(CCCYL), Ministry of Education (ME), Supreme People's Procuratorate(SPP), National Radio and Television Administration (NRTA), Comprehensive Treatment of Social Management Committee (It dissolved in 2018) (CTSMC), Ministry of Public Security(MPS), Ministry of Industry and Information Technology (MIIT), China Cares for the Next Generation Working Committee(CCNGWC), China Food and Drug Administration (It changed into Ministry of Housing and Urban-Rural Development in 2018) (CFDA), Ministry of Commerce(MC), General Administration of Quality Supervision, Inspection and Quarantine (It dissolved in 2018)(GAQSIQ), Central Guidance Commission for Constructing Spiritual Civilization(CGCCSC), Ministry of Railways (It dissolved in 2013)(MR), China Meteorological Administration(CMA), Central Committee of the Communist Party of China (CCCPC), Sate Council(SC).

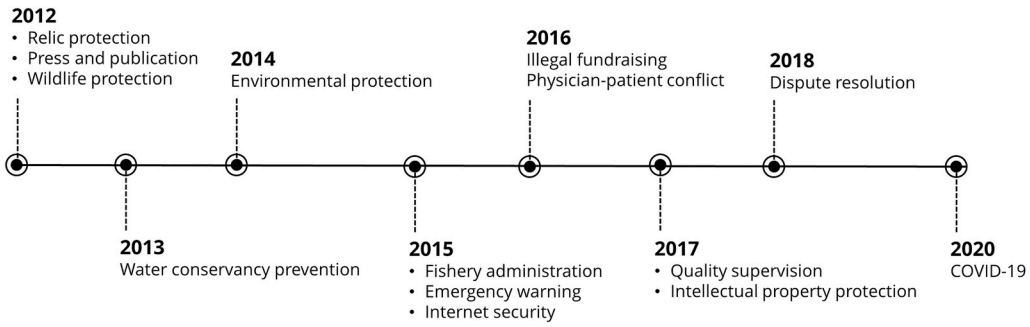

Fig. 12. Time of the first application of PCEWSs for various disasters (2012–2020).

applications in the post policy development phase, and safe production and engineering safety were targeted at this time in 2008. Since then, the role of PCEWSs in disaster recovery and reconstruction based on specific disasters, such as secondary geological disasters caused by earthquakes, has been increasingly designed. Additionally, in 2010, the design of PCEWS applications in disaster emergency disposal with regard to geological hazard prevention and control work appeared. Finally, overall emergency management also employs PCEWSs in "emergency intervention". By the fourth phase of policy development, the General Office of SC issued a notice on the 13th Five-Year plan for

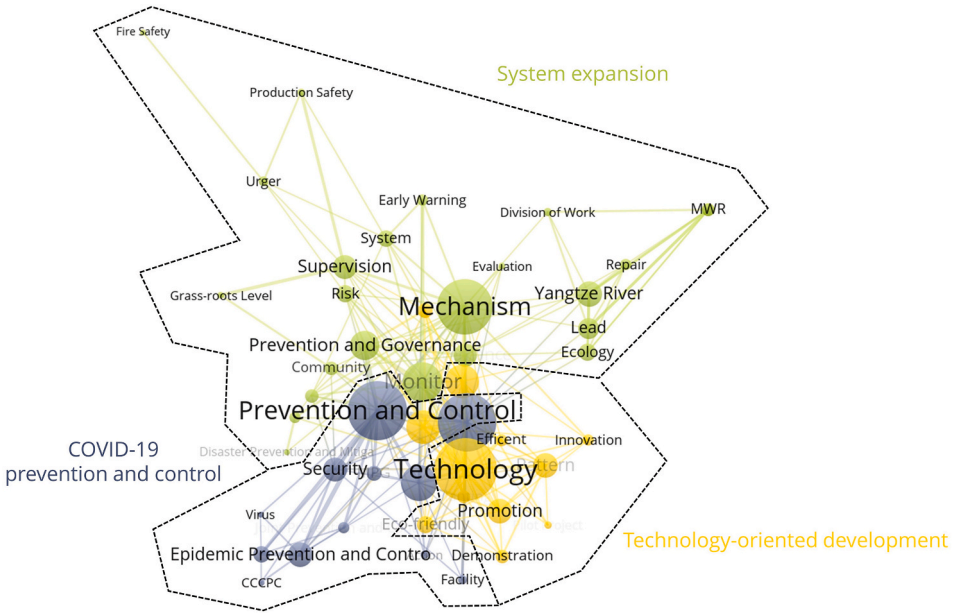

Fig. 13. Co-word analysis and cluster analysis of keywords (2012–2020).

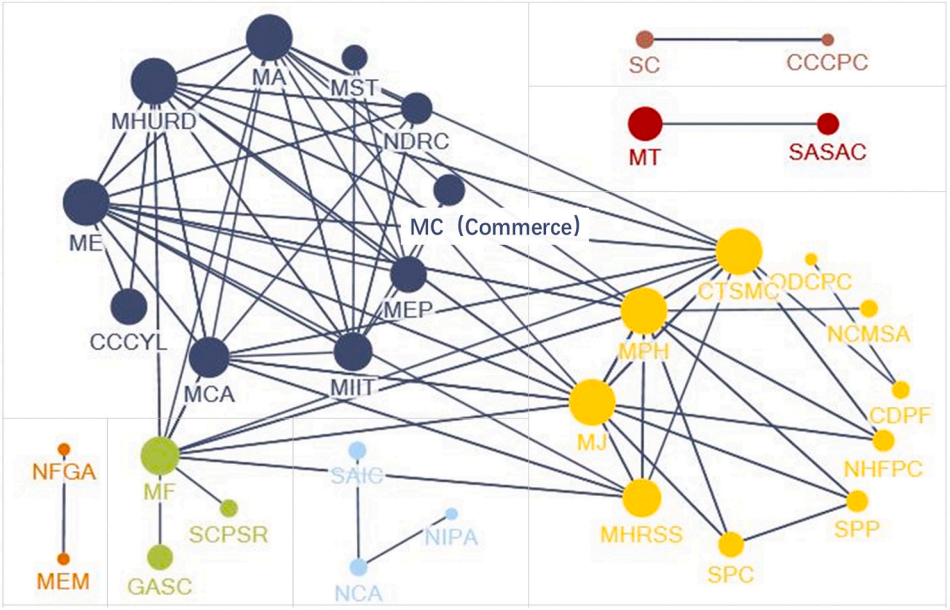

Fig. 14. Network of PCEWS policy-making departments (2012–2020), Acronym: National Core Mine Safety Administration (NCMSA), Ministry of Public Security (MPS), China Disabled Person's Federation (CDPF), Organization Department of the Communist Party of China (ODCPC), Comprehensive Treatment of Social Management Committee (It dissolved in 2018) (CTSMC), Supreme People's Procuratorate (SPP), Supreme People's Court (SPC), Ministry of Justice (MJ), Ministry of Human Resources and Domestic security (MHRSS), National Health and Family Planning Commission (It dissolved in 2018) (NHFPC), Ministry of Agriculture (It changed into Ministry of Agriculture and Rural Affairs in 2018) (MA), Ministry of Commerce (MC(Commerce)), Ministry of Environment Protection (It changed into Ministry of Ecology and Environment in 2018) (MEP), Ministry of Industry and Information Technology (MIIT), Ministry of Science and Technology (MST), Ministry of Education (ME), Ministry of Housing and Urban-Rural Development (MHURD), Ministry of Civil Affairs (MCA), National Development and Reform Commission (NDRC), Central Committee of the Communist Young League (CCCYL), Ministry of Finance (MF), State Commission of Public Sectors Reform (SCPSR), General Administration of Sport of China (GASC), National Copyright Administration (NCA), State Administration for Industry and Commerce (It dissolved in 2018) (SAIC), National Intellectual Property Administration (NIPA), Ministry of Transport (MT), State-owned Assets Supervision and Administration Commission (SASAC), National Forestry and Grassland Administration (NFGA), Ministry of Emergency Management (MEM), Central Committee of the Communist Party of China (CCCPC), Sate Council (SC).

the construction of the national emergency response system to emphasize that public defense autonomy, mass prevention and governance, and personal rescue capabilities should all be strengthened and that the social forces participating in emergency rescue operations need to be supported; of course, the social collaborative response system for emergencies calls for improvement. More importantly, the document

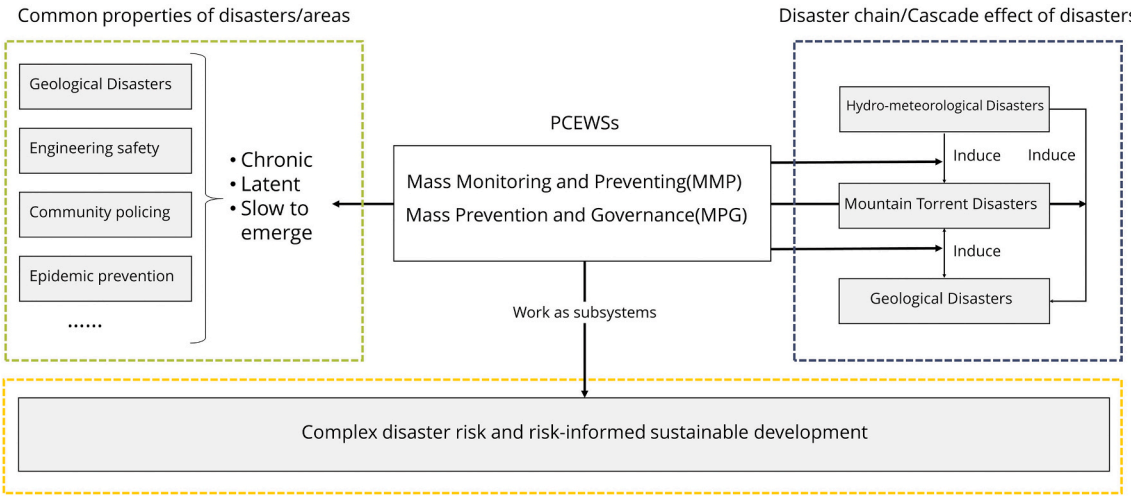

Fig. 15. The role of PCEWSs in China in integrated disasters/areas.

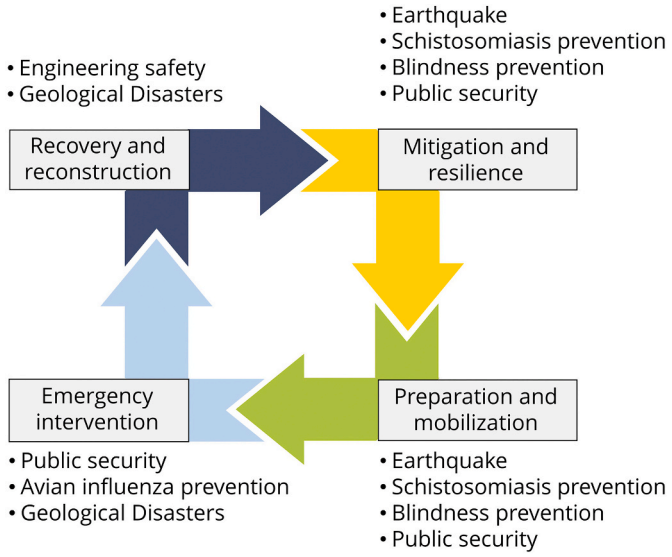

Fig. 16. The main disasters/areas that depend on PCEWSs in four phases of the "disaster cycle".

also pointed out that transformation of emergency management from emergency response to whole-process risk management is needed. This means that from the perspective of overall emergency management, PCEWSs should play a role in emergency rescue.[8]

4.3. From experience-oriented to technology-oriented

PCEWSs have gradually realized development from experience-oriented to technology-oriented organizational forms and resource integration. First, we found that the main words involved in the related policy statement are "a variety of forms, amateur, good experience", which seems abstract and experiential to some extent in the first phase. Then, technology- and science-oriented organizational forms were deepened through the "technology" node, reaching a large degree of co-occurrence in the border junction among the geological disaster subgroup, domestic security subgroup and engineering security subgroup. The network of policy keywords shows that in the engineering safety subgroup, "equipment" clearly appeared. Furthermore, detailed inspection of typical policy documents was carried out, and as in 2001, a policy for geological disasters mentioned a combination of MMP and a professional system for the first time[9], and in this year, the development of a group of precursor monitoring measurement observation instruments was issued by a policy, reflecting the technological orientation of resource mobilization in PCEWS applications for natural disaster areas.[10]

There is also a policy that mentioned "the combination of personnel prevention and technical prevention" in the field of domestic security. Since entering the third and fourth phases, the disaster structure regarding the "emergency" as the center and other areas as coordination has been highlighted in the PCEWS practice in China; accordingly, after the third phase, the model of organizational and resource integration also changed more. Based on the policy network analysis results and combined with the detailed check of typical policies, we found that the organizational form of the third phase presented a focus on embedded technology, with party committee leadership and multiagent coordination. As shown in Figs. 10 and 13, although there is no obvious co-occurrence of high-frequency keywords in the design of organizational forms, the policy keyword "technology" has a central position, especially in the fourth phase of PCEWS development.

In regard to each disaster management policy field, PCEWSs mainly include national-based professional monitoring on hazard, the processing technology and equipment used, and automated warning, which combines with MPG for geological and mountain torrent disaster prevention in the field of natural disasters, enhancing the standards of technology in monitoring and early warning.[11] They also include the

[8] "The Notice that General Office of State Council issued the national emergency response system to build the 13th five-year plan", 2017.http://www.gov.cn/zhengce/content/2017-07/19/content_5211752.htm.

[9] "The Notice that Ministry of Land and Resources on the issuance of the tenth five-year plan for ecological construction and environmental protection of land and resources.",2001. http://www.gov.cn/gongbao/content/2002/content_61360.htm.

[10] "The Notice that Ministry of Science and Technology of the People's Republic of China issued the application guidelines for the key project of the tenth five-year national science and technology research program, "strengthening short-term earthquake prediction and disaster relief technology research",2001. https://code.fabao365.com/law_217073.html.

[11] "The Letter that General Office of Ministry of Land and Resources further strengthened the monitoring and early warning of geological disasters",2009. http://www.cnki.com.cn/Article/CJFDTotal-GTTX200912011.htm.

combination of professional monitoring and citizens observatories group monitoring and the establishment of daily basic information and danger signs reporting and feedback mechanisms for secondary disaster prevention.[12] Additionally, in the field of social safety and accident disasters, they mainly include the deep integration of civil defense, material defense and technical defense, "smart warning" security management in the community, campus safety management, fire safety and safe production. For example, the Ministry of Education (ME) and nine other departments issued that comprehensive governance organizations at all levels should achieve an in-depth integration of civil defense, material defense and technical defense in the grassroots comprehensive governance center,[13] and the Ministry of Civil Affairs (MCA), Ministry of Finance (MF), Ministry of Housing and Urban-Rural Development (MHURD), and Ministry of Emergency Management (MEM) issued similar policies. Finally, in the field of public health, PCEWSs mainly include the overall emergency response to public health emergencies, with the health professional departments as the core, neighborhood committees and the assistance of the masses, disease and pest prevention and control work combining professional teams with mass prevention and treatment, and, more than ever, epidemic prevention and control work related to COVID-19, which requires scientific and accurate prevention and control methods to continue to be embedded in urban and rural communities,[14,15,16].

4.4. Practice-oriented department system support

The comprehensive central departments that adapt to development from diversified disasters to comprehensive disasters. Regarding the change in the disaster structure from multiple to comprehensive, department support mainly presents the trend of a shift from functional departments to comprehensive management departments, which means that not only specialized response agencies but also more collaborative organized agencies with the coordination function to the relevant departments [36,44]. Moreover, the departmental collaborative network in the predevelopment phase shows that the main institutional design subjects of PCEWSs at the national level are mostly functional departments, that is, central ministries and commissions for major disasters—early on, domestic security and geological disasters—among which the MPS and MCA play the most prominent roles. Notably, based on further policy review, we found that civil affairs departments are particularly involved in natural disasters, public health, domestic safety, and accident disasters. In China, a large number of social organizations, community units, and volunteer teams are under the unified leadership of the MCA and its subordinate organizations; thus, their high degree of participation is easy to understand. The certain unique role of MCA was also been highlighted in the whole disaster system in China that it was strongly linked with the Ministry of Finance (MF), China National Commission for Disaster Reduction (CNCDR), National Development & Reform Commission (NDRC), State Administration of Work Safety (SAWS), among others [36]. As shown in Fig. 11, the Central Leading Group for Rural Work (CLGRW), Central Commission for Discipline Inspection (CCDI), Central Leading Group for Stability (CLRS), Central Organization Department (COD) among others. appeared in the third phase. In the fourth phase, the Emergency Management Department (newly established in 2018), the National Development and Reform Commission (NDRC), Central Organization Establishment Committee (COEC), etc. participated.

The coordination of multiple departments that adapt to development from a nonnormalized to a normalized response in the disaster cycle. From the perspective of the departmental collaborative network structure in the first and second phases (Figs. 5 and 8), there is a single category of departments that just conduct work on public security, public health events, and natural disasters. Then Ministry of Education, Central Committee of the Communist Young League (CCCYL), Ministry of Culture (MC), National and Television Administration (NTA), Ministry of Finance (MF), People's Bank of China (PBC), and National Ethnic Affairs Commission(NEAC) (as shown in Fig. 11) appeared in the department collaborative network of the second phase with low frequency, but these nodes become high-degree in the third phase. By the fourth phase, the Ministry of Human Resources and Domestic Security (MHRDS) and the Ministry of Commerce (MC) appear. As stated above, PCEWSs configure the daily disaster preparation, emergency, and post-disaster recovery and reconstruction in the disaster cycle phase, going beyond just the emergency early warning step by step, which inevitably calls for wider and more diverse mobilization and participation as well as practical experience, typical propaganda and popularization. Indeed, more personnel and supplies with support are expected. Therefore, the change in the design of such a system affects its subjects, its services and the concrete practice of PCEWSs.

The participation of materials and technical support departments that adapt to development from experience-oriented situations to technology-oriented situations. Regarding the change in organizational forms from experience-oriented to technology-oriented, department support is particularly obvious and has been highlighted at an early time. In the second phase (1992–2003), the departments in collaborative networks (as shown in Fig. 8) include the MST, China Association for Science and Technology (CAST), and MIIT. Up to the third and fourth phases, the MIIT, General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ), MST, National Intellectual Property Administration (NIPA) and other technical support and maintenance departments maintain a high degree of co-occurrence in the network. Based on the analysis above, we conclude that each central comprehensive department, and the functional department has strengthened the technology in equipment procurement, personnel training, etc., and gradually achieved the development of technology centers. Moreover, the MST, intellectual property offices, and other departments have further guided the development of the technology from the outside, advancing PCEWS practice in China. It is worth mentioning that these government agencies manage different public affairs of people in local communities who works for different industries or occupations, which reflects the joint participation of people to some extent. Additionally, the deep analysis and discussion about local communities' participation and the network is such an interesting point that further attention can be payed.

4.5. The Chinese PCEWSs' experience and its revelation

The four main characteristics of PCEWS's development in China discussed above indicate that PCEWS role embed into disaster or emergency, even risk governance beyond the original connotation, which is "early warning". If PCEWSs were used at the beginning because of economic and technical capacity limitations in China, the widespread use of PCEWSs now proves the strong vitality of this system. Such a

[12] "The Notice of the coal, electricity, oil transport and emergency response and disaster response command center of the state council (No.9)",2008. http://www.gov.cn/govweb/gzdt/2008-02/05/content_884354.htm.

[13] "The Guidance that Ministry of Education and other nine departments on the prevention of bullying and violence among primary and middle school students",2016. http://www.moe.gov.cn/srcsite/A06/s3325/201611/t20161111_288490.html.

[14] "The Notice that General Office of Ministry of Public Health on the issuance of the guidelines for the compilation of community (township) emergency plans for public health emergencies (trial)",2006. https://www.lawxp.com/statute/s527257.html.

[15] "The Notice from State Forestry Administration's American white moth control mission in 2008",2008. http://www.forestry.gov.cn/main/4461/content-733464.html.

[16] "The Notice that joint prevention and control mechanism of State Council issued to further guide the implementation of the prevention and control strategies in different regions at different levels",2020. http://www.gov.cn/xinwen/2020-02/29/content_5485010.htm.

transition or the whole course of development seems consistent or mutually reinforcing with the pattern of disaster system policy in China, according to the findings and conclusion of Zhang et al., 2018 [36]. Facing the increasing disaster and risk, a low-cost and efficient EWS is an essential prerequisite of successful disaster management. The best way to improve resistance to risk is to mobilize the masses to fully guide the grass-roots participation. Inclusion and participation contribute greatly to governance, the people-centered institutions and mechanisms should be attached more attention and promoted in risk management all over the world. Chinese PCEWSs experience may have implications for both developing and developed countries.

First, PCEWSs are not everything, however, PCEWSs play an important role in nonsudden or chronic disasters and the disaster association or the disaster synthesis formed by the disaster chain. So, it's very important to study the characteristics of disasters, especially the early signs of disasters. At the stage when disasters and emergencies enter into systematic management, PCEWS has been paid more attention to in the field of natural disasters, especially geological disasters, and has been embedded into the framework of national emergency management to a greater extent. At a time when economic development was priority and disaster reduction was largely integrated into the overall national economic and social strategy, PCEWSS were actually applied more in the field of public security or societal resilience. PCEWSs play different role in the disaster management circle.

Second, combined the experience and technology. When we cannot apply the advancing technology to EWS due to many kinds of factors, it's a good way to rely on widely people's participation and their experience, even if it may be not so accurate. However, with the development of economy, society science and technology, PCEWSs have gradually developed from experience-to technology-oriented. Moving into the disaster and risk governance phase, PCEWSs drive the responsibility of citizens in the effort to reduce risks and disaster impacts, which serves a complement for technical capacity for disaster management.

Last but not least, multi agent participation is needed in PCEWSs. The change in the application period from nonnormal to normal in the overall disaster cycle, department support mainly presents a trend of expanding to multiple fields. In the late stages of policy development, with several functional departments maintaining a higher degree of participation and cooperation at the same time, more and more comprehensive departments are embedded through cooperation with other business units (in the network structure, this is a kind of cooperation, and in the process of practice, it is a kind of command) to carry out the work of PCEWSs.

5. Conclusion

Because of the ravages of epidemics and disasters, China realized after major earthquake and the SARS event in 2003 the importance of people-centered early warning systems as part of disaster management policy. Aiming to present China's PCEWS practice in multiple dimensions, co-word analysis and cluster analysis were employed to describe and visualize the development of institutional design priorities by policy keywords and policy-making department networks in four phases. Four main tendencies of PCEWSs were identified. The objects of PCEWSs changed from diversified disasters to disaster synthesis. The embedded time points of PCEWSs changed from non-normalization to normalization in the "disaster cycle". The organizational forms of PCEWSs changed from experience-oriented to technology-oriented. The implementation departments of PCEWSs supported all institutional transitions among disaster synthesis, normalization and technology-oriented organizational forms. Notably, certain experience includes the disaster characteristics that PCEWSs are suitable to get involved, the orientation that experience and technology should be combined and multi agent participation which calls for more emphasis may serve as a basis for exploring the effective PCEWSs globally.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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