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Research article

Evaluation on sustainable development of fire safety management policies in smart cities based on big data

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Abstract: The fire safety management policy is the premise for city managers to master the urban fire safety situation and solve the urban fire safety problems. An excellent fire safety management policy can obtain the basic data of fire safety, analyze the existing problems and potential safety hazards, and provide targeted measures for urban fire safety management. At present, the traditional fire safety management policy has exposed many shortcomings, such as the lack of technical support for firefighting means, inaccurate fire data analysis, etc., which ultimately led to low fire extinguishing efficiency and wasted some human and material resources. In the context of smart cities, big data (BD) and artificial intelligence (AI) have gradually integrated into various fields of urban development. This paper studied the fire safety management policies of smart cities based on BD analysis method. First, it summarized the relationship among BD, AI and smart cities, then analyzed the limitations of traditional urban fire safety management models, and finally proposed new fire safety management methods based on BD, AI and sustainable development. This article analyzed the urban fire protection situation from January to June 2022 in Nanchang, and verified the effectiveness of the method proposed in this article. Research has shown that the new fire safety management policy has reduced the number of fires, improved fire extinguishing efficiency by 9.07%, reduced property damage and casualties, and has a high recognition of the method. This also provides a reference for the next step of BD's application in smart cities.

Keywords: fire warning; fire safety management; smart city; sustainable development; big data technology

1. Introduction

With the acceleration of urban development, the fire safety situation is becoming increasingly severe. In recent years, the integration of modern information technology has led to the birth of smart cities, which brings opportunities for urban development as well as challenges to fire safety management. The traditional fire safety management policy is highly restrictive, and the management mode is relatively backward, which has brought some obstacles to the fire work, and ultimately led to the unsatisfactory result of fire accident handling. In the new situation, it is an attempt and innovation to bring BD and AI applications to smart city fire safety management policies.

Fire safety management is an important guarantee to promote the development of urban safety, and many people have studied it. Salleh et al. suggested taking the fire safety management plan as a feasible measure to solve the technical, management and legislative factors and pointed out that the government should timely upgrade the fire safety technical equipment to ensure the solution of the problem [1]. Spinardi et al. believed that only relying on the annual death statistics to guide the fire safety management policy could not solve the defects in the actual work, and then pointed out that a series of evidences should be integrated into the fire safety management policy [2]. Alao et al. discussed the factors affecting the improper management of fire safety. Research showed that insufficient safety training and non-compliance of fire safety are the biggest factors affecting improper fire safety management [3]. Benson et al. analyzed the reason the fire protection expertise could not be fully used for fire safety management in the process of building planning. Finally, it was concluded that the construction supervision system may be one of the many problems that lead to fire safety problems [4]. Ebenehi et al. studied methods to ensure that buildings in higher education are not affected by fires, which ultimately provides an effective fire safety management framework for buildings in higher education institutions [5]. Roslan et al. has built a fire safety management system to prevent traditional building fires. The practice showed that the prevention effect of the system is good [6]. Mutinda et al. discussed how to promote the development of fire safety management policies [7]. Finally, it was concluded that fire drill and fire risk assessment are two important measures to promote the development of fire safety management policies [7]. These works on fire safety management are referential, but they are not applied to BD.

With the maturity of BD technology, its application in fire is increasingly extensive. Agarwal et al. analyzed the role of fire event occurrence status in determining fire risk and finally provided useful insights for fire managers and researchers in the form of BD and prediction analysis [8]. Kim et al. applied BD to the data analysis of fire accidents on construction sites. Practice has proved that this analysis method is very effective and can be successfully used to derive a large amount of text data in the future [9]. Lu et al. built a stadium fire risk assessment model based on BD. The research showed that the model has good accuracy in monitoring data and evaluation effect [10]. Khalid et al. proposed a fire monitoring system based on BD to guide the investigation of a series of industrial fires. Practice showed that the system performs well in fire monitoring and data storage [11]. Park et al. conducted BD analysis on the factors causing fire and then applied them to the standardized fire prediction platform through data preprocessing [12]. Joo et al. tried to use BD to determine the indicators needed for building fire risk assessment. Research methods showed that BD analysis can be used to formulate measures to reduce building fire risk, and the determined risk indicators can be used as reference materials for evaluation [13]. Zhang et al. applied the BD clustering algorithm to the intelligent fire early warning system. The simulation results showed that the system has high data fusion accuracy and good clustering [14]. The above research on the application of BD in fire is more specific, but it does not involve the fire safety management policy of smart cities.

In the context of smart cities, all areas of cities are moving towards intelligent development. Fire safety management policy is the theoretical basis for preventing and dealing with urban fire accidents. With the development of urban intelligence, intelligent fire protection came into being. This paper applies BD and AI to fire safety management policies in combination with the concept of smart fire protection, and provides sustainable development measures. The experimental results show that the new policy proposed in this paper can effectively reduce direct property loss and casualties in fire accidents, providing a reference for fire safety management in smart cities.

2. Feasibility of combining BD, AI with smart city fire management

The so-called smart city means that the city is developing towards intelligence. With the progress of science and technology, urban intelligence has gradually become a hot topic. The vigorous development of BD and AI has not only injected new impetus into urban economy and urban development, but also gradually changed people's lifestyle.

Urban data is the specific embodiment of urban operation and development. Comprehensive and accurate data can provide a certain basis for development policies.

In the new situation, if cities want to develop intelligently, they must fully master the BD of production, life and operation management. The more data used in urban intelligence, the more accurate the results would be [15]. Similarly, AI and urban intelligence are mutually reinforcing and achieving. Relevant technologies and algorithms in AI can provide advanced means for urban intelligence, and urban intelligence can provide valuable advice for the next step of AI development [16].

Essentially, the application of technologies such as BD, artificial intelligence, and smart cities is a manifestation of information technology to a certain extent, with centralized and systemic characteristics. Applying intelligent fire protection to social fire safety management can strengthen the quality and comprehensive maintenance of building fire protection facilities in social units, thereby comprehensively improving the standardization and intelligence level of social fire safety management. It is conducive to improving the relevant skills of fire management personnel and alleviating the problem of insufficient fire police force. At the same time, it can also achieve the interconnection and exchange of public fire management information and resources, implementing the construction of mobile office and remote supervision models [17].

3. The necessity of applying intelligent fire protection technology to fire safety management

The traditional urban fire safety management mode is to learn from experience and then summarize preventive measures after fire accidents. This fire management mode is a passive postevent management mode, which can well solve the conventional fire problems, but in the face of new situations and new problems, there would be a lack of active means and methods to effectively deal with these problems [18].

Under the background of smart city, with the rapid development of urbanization and the acceleration of industrialization, the situation of fire prevention would become increasingly severe. The continuous emergence of new materials, technologies, equipment and energy will bring various new problems, and the factors that trigger fires will become diverse and complex, which will pose challenges to fire safety management. The shortcomings of traditional fire safety management models that lack technical support will gradually be exposed. When the limitations of the old management model become greater and greater, the urban fire safety management policy would have to be changed.

As shown in Figure 1, various fields under the smart city will generate a large amount of data, including social data, energy consumption data (water, electricity, natural gas, etc.), transportation data, consumption data, logistics data, environmental data, etc. These data come from urban infrastructure, governments, enterprises, remote sensing satellites, etc., providing necessary information for urban management and planning [19]. Applying artificial intelligence and BD technology to the collection and calculation of urban data will greatly improve the level of urban planning and urban operation efficiency, which is also crucial to urban energy supply, transportation planning, and urban environmental planning.

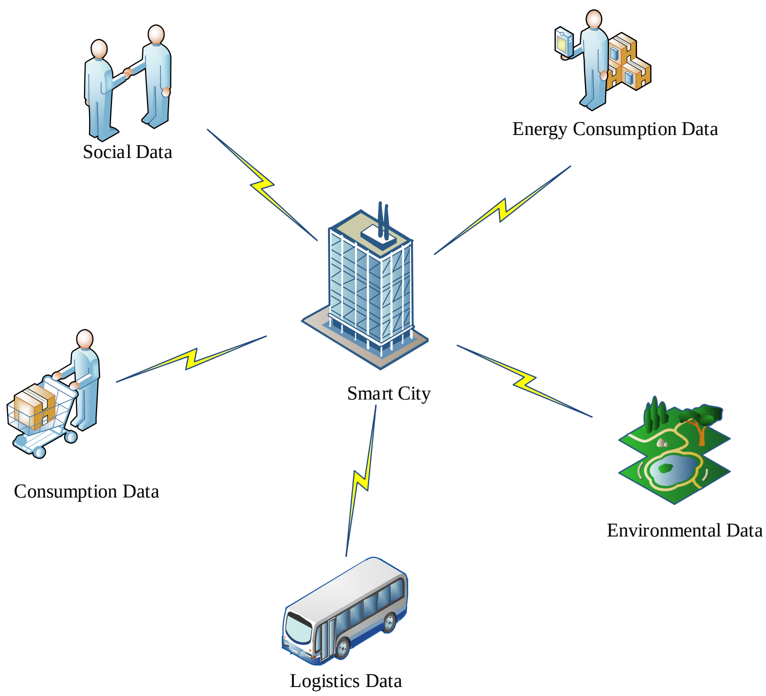

Figure 1. Various data under smart cities.

The application of intelligent firefighting technology in fire safety management can achieve effective connection between real objects and the Internet through the constructed protocol. It can also effectively spread relevant information through sensing facilities, providing assurance for scientific scheduling and allocation of human and material resources, and achieving positioning, monitoring, and tracking of fire safety situations in different regions. This can effectively avoid the drawbacks of traditional manual operations, identify existing fire hazards more effectively, and significantly improve the level of social fire safety management [20]. Because with the help of intelligent fire protection technology, it is possible to better supervise the implementation of fire safety management responsibilities by social units, thereby ensuring that all work carried out by social units is consistent with safety management regulations, fundamentally eliminating the problem of fire safety management being a mere formality. Under the real-time and efficient supervision function, certain control has been exercised over the responsible personnel for fire accidents, making the occurrence of fire accidents more scientific. At the same time, it can also improve the management of fire-fighting equipment in social units, make regular inspection and maintenance work easier, and enable fire-fighting equipment to play its role normally. In addition, it can also provide convenience for conducting education, training, and management work for fire safety responsible persons, which is also of great help in improving the overall quality of fire safety responsible persons.

In addition, by building a smart fire protection system and fully leveraging the advantages of smart fire protection technology, it is possible to innovate and transform the fire safety management mode, and carry out remote supervision work from the perspective of data interconnection, resource sharing, and information exchange [21]. Through laser scanning, GPS positioning system, infrared sensor, and other equipment, based on the Internet of Things technology and big data technology, information and data can be effectively integrated and collected to achieve real-time data transmission and sharing. Data analysis and processing can be completed by computer. Thus, a more systematic and comprehensive social fire safety management system has been formed, which can effectively implement fire safety management work through intelligent and digital means. Against the backdrop of the rapid development of smart cities, the development prospects of smart fire protection technology are very broad and have great development potential. While building an intelligent fire protection system to improve the level of intelligence in social fire safety management, it also needs to be based on the current situation of fire safety management. By continuously improving system functions, optimizing various resource configurations, and improving information management efficiency, all security risks can be eliminated, and the speed of fire rescue can be increased to make up for some shortcomings in social fire safety management.

4. Fire safety management method based on BD and AI in smart cities

4.1. Application strategy of BD

4.1.1. Analysis of historical fire data

BD analysis is a widely used technology in the study of historical fire data. Combined with BD analysis methods, it can study the temporal and spatial characteristics of historical fires, strengthen fire safety in key areas, and determine the impact of fires through remote sensing monitoring data. In addition, the data classification method can be used to summarize the space and time rules of fire sources when dealing with regional fire hot spots, and then focus on the fire area control [22].

4.1.2. Fire research methods

BD technology is accurate and fast in processing data. According to this feature, this technology can be used to upgrade the fire early warning system and build a more accurate and regional targeted early warning system. As an advanced computing tool, BD technology allows the acquisition and simplification of data through empirical methods and can accurately process the acquired data. With this technology, the fire early warning system would save a lot of manpower and material resources and can improve the system efficiency.

4.1.3. Fire prevention and control

Under the new conditions, the fire service has changed from public fire service to public fire supervision. The concept of comprehensive supervision runs through the whole process of governance, forming a new model of social fire safety management with multilevel governance, unified governance, shared participation, and shared fire protection. The data collection system and transmission equipment (including fire detector and fire equipment) based on BD technology are stable and reliable, which realizes the automation and intelligence of fire prevention and control.

4.1.4. Fire fighting and rescue

As shown in Figure 2, in the age of BD, all fire protection information is real-time and accurate from the beginning to the end of the fire. After receiving the information, fire personnel can deploy in advance to complete the fire fighting task for the first time. The BD analysis method collects all information on the fire scene in real time from the beginning of the alarm, which not only supports the arrangement and decision-making of fire fighting tasks, but also helps to evaluate the property loss and casualties caused by fire accidents after fire fighting.

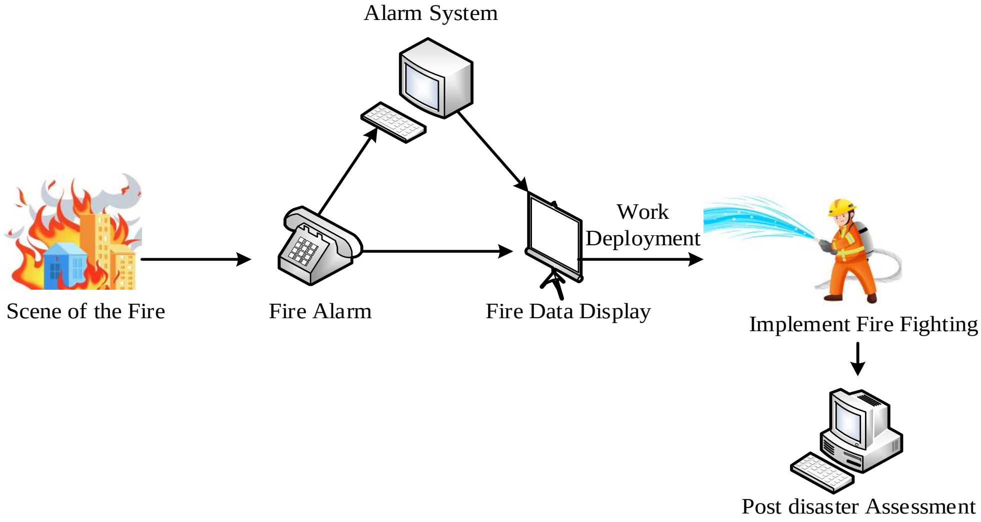

Figure 2. Fire fighting and rescue process in the age of BD.

4.1.5. Fire situation prediction

The fire site is the place where the fire occurs. There are many reasons for the fire. They are not only the appearance of open fire, but also may be caused by lightning, which requires early warning. At the actual fire scene, the spread speed and direction of the fire, the flame intensity, height, temperature, and smoke may change at any time. The staff must determine the fire fighting and evacuation routes as soon as possible. BD technology can conduct real-time simulation through corresponding algorithms to calculate the location of the fire site to better support firefighting tasks and better protect the safety of firefighters [23].

4.1.6. Fire loss assessment and fire cause investigation

BD technology can comprehensively summarize the data of property and personnel before the fire and scientifically assess the fire loss according to the situation after the fire, and the assessment results can be used as the basis for insurance companies to compensate and judge. At the same time, collecting detailed information about the fire site, especially the burning traces of the building, helps to investigate the cause of the fire in depth and draw scientific conclusions [24].

4.2. Application of AI in the identification of major fire hazards

On this basis, a new method based on computer vision technology is proposed. The research focus of this paper is to use artificial intelligence technology to detect key fire hazards. In previous fire identification, manual methods were often used to identify major fires and process fire information. The processing requirements for fire information were relatively high. In addition, due to the complexity of the fire situation and the high requirements for firefighting technicians, the efficiency of fire identification and classification work is low. When using artificial intelligence for identification, the first step is to teach it a specialized identification method. After completing their studies, students can replace experts in their work, greatly improving work efficiency, especially saving a lot of human resources [25]. This paper introduces a method of fire hazard identification based on artificial intelligence.

In this article, the theory of color channels and color modes is applied to the processing of flame images. RGB color mode is a commonly used color benchmark, which changes the red, green, and blue color channels to present different colors in color images. The modeling method for hyperspectral remote sensing images based on the human eye adopts three parameters: H (hue), S (saturation), and I (brightness). Combining the respective characteristics of these two color modes, the RGB color space is converted into HSI color space, and then the fire image is preprocessed. This method uses the HSI model to separate the color and brightness information of the image. In subsequent image processing, only the I component is needed to reflect the characteristics of the fire image without affecting the color information. It can also avoid color distortion problems when processing RGB color space.

The HSI color model has color definitions related to standardized red, green, and blue, and its component coefficients meet the following formulas:

$$r = \frac{R}{R+G+B} \tag{1}$$

$$g = \frac{G}{R+G+B} \tag{2}$$

$$b = \frac{B}{R+G+B} \tag{3}$$

The expression of the HSI model is as follows:

$$I = \frac{1}{3}(R + G + B) \tag{4}$$

The H expression of the HSI model is as follows:

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{(R-G)^2+(R-B)(G-B)^{\frac{1}{2}}}\right\} \tag{5}$$

The S expression of the HSI model is as follows:

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \tag{6}$$

On this basis, the transformation from RGB color space to HSI color model is completed. Because flames are usually yellow and red in color, their saturation will be high in HSI color mode. Based on the above characteristics, a preliminary judgment can be made on the fire.

4.2.1. Image binarization

A new image-based real-time flame detection method has been proposed by scholars. Firstly, by analyzing 70 flame images, the flame features based on the HSI color model were extracted. Then, based on these flame features, roughly separate areas with fire-like colors from the image. In addition to segmenting the flame area, background objects with similar flame colors or color shifts caused by flame reflection are also separated from the image [26]. Binary images can maximize the difference between the flame object and the background, providing convenience for future data processing. In addition, since the color and saturation of flame pixels largely depend on the color of the flame, in actual processing, flame pixels can be 1 pixel, while non flame pixels can be 0 pixels. Usually, the selection of thresholds mainly relies on experience. This project plans to use the OTSU (NobuyukiOtsu) method for threshold selection and binarize it.

4.2.2. Image feature extraction

The gray level co-occurrence matrix utilizes the spatial correlation of gray levels to describe texture features, and Gray Level Co occurrence Matrix (GLCM) uses this feature to describe texture features. (Gray level co-occurrence matrix refers to a commonly used method of describing textures by studying the spatial correlation characteristics of gray levels. Because the texture is formed by the repeated occurrence of the gray distribution in the spatial position, there will be a certain gray relationship between two pixels at a certain distance in the image space, that is, the spatial correlation characteristics of the gray in the image.) However, due to the large amount of data it contains, it is usually not applied in practice, but rather converted into a certain number of statistics and texture features. Three statistics were used in the article: contrast, correlation, and energy, where G represents the grayscale co-occurrence matrix.

The contrast reflects the relationship between the sharpness of the image and the depth of the texture, calculated as follows:

$$\text{Contrast} = \sum_i \sum_j (i-j)^2 G(i,j) \tag{7}$$

Contrast represents the GLCM matrix in frequency form.

The correlation reflects whether the texture of the image is consistent, calculated as follows:

$$\mathrm{Correlation} = \sum_{i=1}^{k} \sum_{j-1}^{k} \frac{(ij)G(i,j) - u_i u_j}{s_i s_j} \tag{8}$$

S_i represents the average number of pixels, S_j represents the product of the average number of pixels and variance.

Energy is the sum of squares of the values of each element in the matrix, which reflects the uniformity of the gray distribution and the thickness of the texture. The specific calculation method is:

$$\mathrm{Energy} = \sum_i \sum_j G(i,j)^2 \tag{9}$$

4.2.3. Fire identification based on support vector machine (SVM)

This article uses MATLAB 2018 to perform machine learning on multifeature fusion fire and applies it to fire classification and recognition. In the process of establishing a support vector machine, the template support vector machine is first used to set the learning parameters, and then the Fitsecoc function is used to establish the model of the support vector machine. This article uses current flame monitoring methods: smoke sensors and temperature sensors. Then, based on RGB and HIS color space model, this article combines the three-frame difference method, ViBe background difference algorithm, and SVM to recognize flames and classifies pixels. During the prediction process, we use the prediction function to predict sample categories.

4.3. Combining smart fire fighting to promote sustainable development

Smart fire protection is a new concept and practice of fire safety management at present, and a fire safety management mode based on cloud computing, BD, Internet of Things, and other modern advanced technologies. To solve the sustainable development problem of smart fire protection or fire safety management in smart cities, people need to consider it from multiple perspectives.

Connection between technology and market: in smart fire protection, fire protection technology has been very advanced and comprehensive, but the only disadvantage is that the application scenario is insufficient. Moreover, the technology cannot be tested and applied, which ultimately hinders the further development of the technology. In view of this situation, the government should give full play to its leadership role and actively guide relevant units to promote intelligent fire protection technology through fire drill activities. These activities are not administrative orders, but cost-effective means. Relevant units or companies can obtain corresponding benefits through preferential policies such as taxation, insurance, and subsidies. At the same time, the application of the market can expand the smart fire protection market, reflect the new technical problems urgently needed to be solved by scientific research, and form a virtuous circle.

The integration of intelligent construction: the initial stage of intelligent fire protection construction is the data perception construction stage. For example, the current fire remote monitoring system only has a single data collection. To achieve a breakthrough, people must solve the problem of horizontal data flow and gradually enter the data mining stage. Smart firefighting is not an isolated battle. Intelligent transportation facilities, intelligent fire engines, and intelligent firefighting network systems are important components of smart city construction. By actively integrating these intelligent constructions into smart fire protection, data perception would be more intelligent and comprehensive, and smart fire protection would eventually enter the application stage, ensuring its sustainable development.

The public's understanding of smart fire protection: building smart fire protection requires a mass base, but the public knows little about the system. At present, fire protection propaganda only focuses on some common sense of fire protection, such as the use of fire extinguishers, fire escape, etc. In the context of smart cities, staff should combine BD and AI to build a virtual platform for smart city firefighting and produce smart city firefighting videos. This can make the public feel the application of technology in fire safety management, establish public confidence, and enable them to support the development of fire safety in the long term.

5. Evaluation of experimental results of new fire safety management policies

Under the background of smart city, in order to upgrade the fire safety management policy and realize smart fire protection, this paper applies BD and AI to the new policy and gives the sustainable development strategy. In view of the implementation effect of the new fire safety management policy, the following experiments were designed.

For the new policy on fire safety management, this article analyzes the fire situation in Nanchang City from January to June 2022. For the traditional policy, this article searches for data from previous years without implementing new regulations. The data is sourced from the official website of the National Fire and Rescue Bureau and is replaced by city A.

First of all, under the application of traditional fire safety management policies and new fire safety management policies, the number of fires in the city A from January to June was investigated. The investigation results are shown in Figure 3. The names of the two fire safety management policies in the figure are referred to as traditional policy and new policy for short.

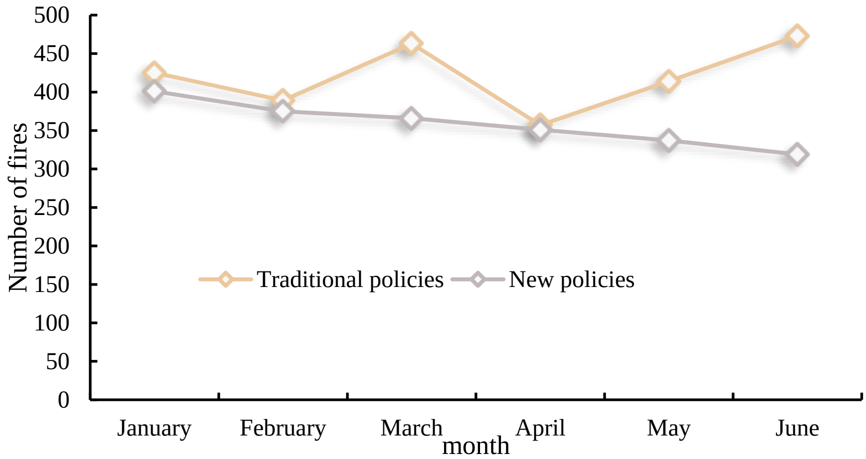

Figure 3. Number of fires in the city A from January to June under the two policies.

It can be seen from the line chart in Figure 3 that under the implementation of traditional policies, the number of fires in the city A exceeded 400 in January, decreased briefly in February, increased again in March, decreased a little more in April, and then continued to increase in May and June. On the whole, the number of fires was high and low. On the other hand, the number of fires in the city A in 6 months under the new policy was less than 400 in January and showed a continuous downward trend in the following months, which shows that the implementation of the new policy can reduce the frequency of fire accidents.

Property loss and casualties are the two most common types of loss in fire accidents. From the degree of loss, it may affect normal life at least, and it may lead to family destruction and death at worst. In order to verify whether the implementation of the new policy can reduce direct property losses and casualties, this article investigates the average direct property losses and casualties of each fire accident in residential areas, factory areas, commercial areas, and, vehicle fire areas of A city under the application of the new policy. It was compared with the average direct property loss and average casualties under traditional policies in the past. The comparison results are shown in Figures 4 and 5.

In the upper histogram, Figure 4 represents the average amount of direct property loss under the two policies, and Figure 5 represents the average number of casualties under the two policies. It can be seen that in the four types of fire areas under the traditional policy or the new policy, the highest average property loss was in the commercial area, and the lowest was in the transportation. In terms of the number of casualties, the residential area with the highest number of casualties in the four types of fire areas under the two policies still had the lowest number of vehicles. By comparing the average property losses and casualties under the two policies, it can be concluded that the average property losses and casualties in the four types of fire zones under the new policy are much lower than under the traditional policy, which shows that the new policy is effective in reducing property losses and casualties. Fire extinguishing efficiency is an important prerequisite to reduce property loss and casualties in fire accidents. In order to understand the fire extinguishing efficiency under the new policy, the fire extinguishing efficiency of 10 fire fighting tasks in the city A was investigated under the new policy, and compared with the 10 fire extinguishing efficiencies under the traditional efficiency. The comparison results are shown in Figure 6.

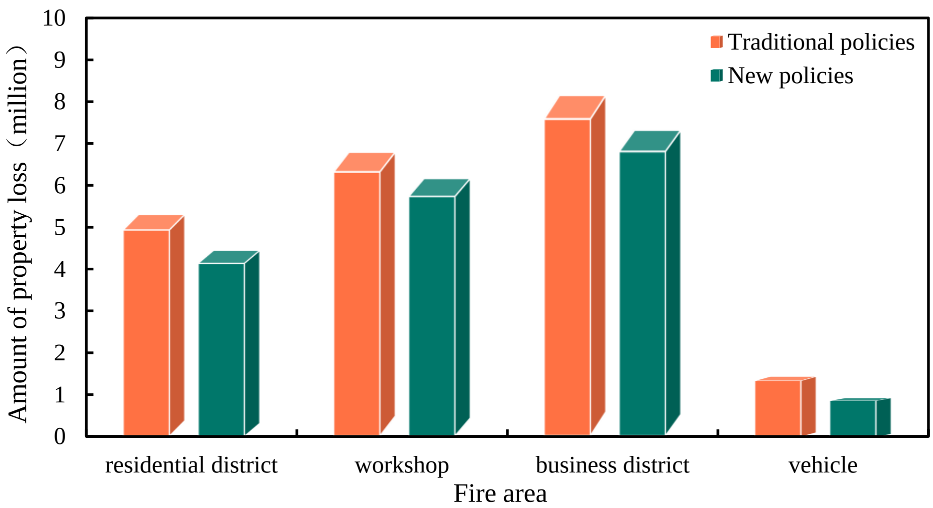

Figure 4. Average amount of direct property loss under the two policies.

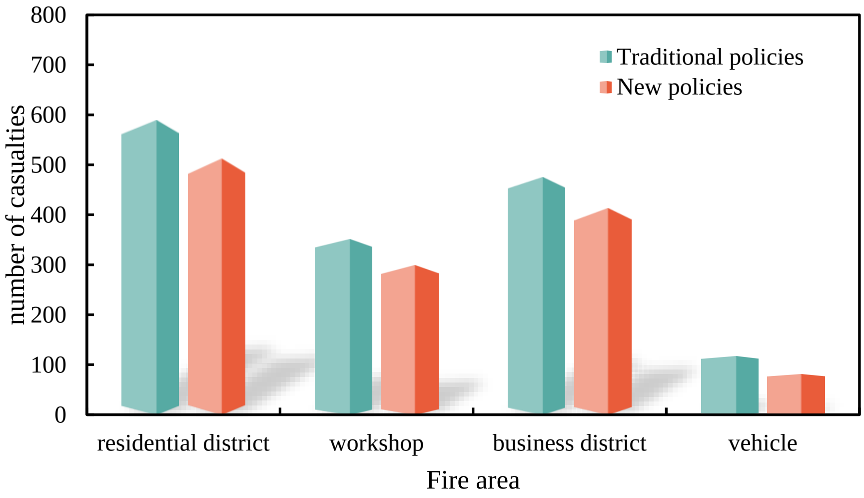

Figure 5. Average casualties under the two policies.

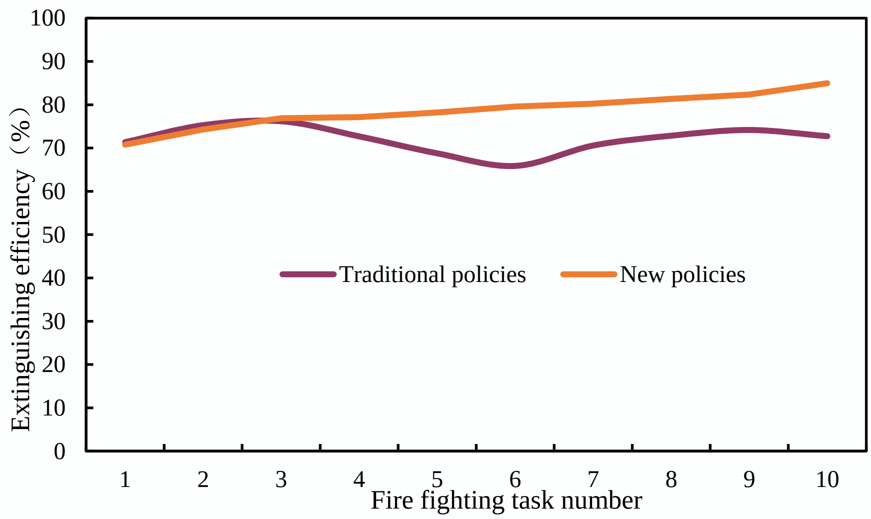

Figure 6. Extinguishing efficiency of 10 fire fighting tasks in the city A under two policies.

It can be concluded from the above curve that, in the first two firefighting tasks, although the firefighting efficiency under the new policy was lower than that under the traditional policy, the efficiency value remained above 70%. The reason the efficiency was lower than that of the traditional policy was that it has just been implemented, and many aspects were not well adapted. Since the third firefighting task, the firefighting efficiency under the new policy has always been higher than that under the traditional policy, and it was a steadily rising trend. In contrast, the firefighting efficiency under the traditional policy began to decline from the third firefighting task. Although it rose again several times later, the overall firefighting efficiency was not as good as the new policy. In contrast, the firefighting efficiency under the new policy was 9.07% higher than that under the traditional policy.

The implementation of the new fire safety management policy should not only be recognized by firefighters, but also by residents, regulatory agencies, and leadership. After the implementation of the new policy, this paper investigated the recognition of the four categories of personnel in the city A with the new fire safety management policy, including 100 residents, fire fighters, regulatory authorities, and leadership. The degree of recognition can be divided into recognized, recognized, and not recognized, as shown in Table 1.

Table 1. Recognition of the new fire safety management policy by the four categories of personnel in city A.

	Resident	Fire fighter	Regulatory authorities	Leadership
Highly recognized	56	59	51	49
approval	37	32	38	37
Disapproval	7	9	11	14

According to the data in Table 1, most of the four categories of personnel were highly recognized and recognized, and the number of people who did not approve was very small. The maximum number was no more than 15, which indicates that the new fire safety management policy can be recognized.

6. Conclusions

With the support of science and technology and the concept of sustainability, traditional cities are transforming into smart cities. In a smart city, there are more uncertain factors of fire, which requires more comprehensive fire safety management policies. With the growing maturity of BD and AI technology, applying these two technologies to the new fire safety management policy would certainly bring updates to fire protection measures and equipment, and would also provide power for the safe and smooth development of smart cities. However, after on-site investigation, it was found that the current intelligent fire-fighting operating system still has the following shortcomings: it cannot deal with dereliction of duty qualitatively and quantitatively. Overall, the application terminals of the system are mainly personal computer terminals, and mobile terminals such as mobile phones and iPad cannot be widely popularized. The formulation of the emergency evacuation exercise model and fire extinguishing plan for key units is at the surface level. The development of the Internet of Things has accelerated the construction process of urban intelligent fire protection systems, especially the combination of intelligence and application of fire protection systems, the innovation of systems and mechanisms, and the promotion of big data resource interconnection. In the future, the research direction of this paper is to strengthen the safety management of big data at the same time, but the informatization development level of cities is different, so the local actual situation should be considered while building the intelligent fire protection system, and measures should be taken according to local conditions. Overall, the application of intelligent fire protection technology in social fire safety management is still in the practical exploration stage, and it is necessary for relevant functional departments and research enterprises to strengthen their research on this technology to improve the functionality and effectiveness of the system.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare that there is no conflict of interest.

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