Preliminary Study on Forest Fire Prevention and Extinguishing in Townships in the Southern Mountainous Areas of Zhejiang Province: A Case Study of Lishui

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Abstract Forest fires seriously threaten forestry resources and the life and property safety of people in mountainous areas of Lishui City. In this paper, a fire prevention concept with refined forecast and early warning of forest fire danger weather ratings in townships as the starting point, satellite real-time observation of fire spots, monitoring of the Internet of Things and other high-tech products as an implementation means, and strengthening forest fire prevention equipment and personnel in townships as a guarantee was established. The command system for rapid emergency response by cities, counties and townships should be improved. During the forest fire prevention period, fire sources should be strictly controlled, and the basic principles of forest fire fighting in townships should be implemented into the actual fire prevention and fire fighting work to eliminate forest fires in time at the initial stage and before the disaster.

Key words Mountainous areas of southern Zhejiang; Townships; Forest fire danger

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In recent years, extreme hot weather has swept all over the China, and the phenomenon of global warming has become increasingly aggravated. Continuous hot weather has led to the constant occurrence of mountain fires in China, which has seriously threatened national forest resources and people's life and property safety[1-11]. A mountain fire in Muli County, Liangshan Prefecture led to the deaths of 30 fire-fighting personnel in 2019, and a forest fire in Xichang City, Liangshan Prefecture killed 19 people in 2020. Only in the first half of 2023, a total of 240 forest fires occurred in China, so the situation of fire prevention is still very serious. The Party Central Committee and The State Council attach great importance to forest fire prevention. In April 2023, the General Offices of the CPC Central Committee and The State Council issued the *Opinions on Comprehensively Strengthening the Work of fire Prevention in Forests and Grasslands under the New Situation*, and with the main goal is that by 2025, the damage rate of forest and grassland fires will be controlled within 0.9‰ and 2‰, respectively. By 2030, the ability to prevent and extinguish fires in forests and grasslands will be significantly enhanced; the public's awareness of fire prevention and the rule of law will continue to improve, and the level of comprehensive prevention and control will be improved in an all-round way.

The mountainous area in the south of Zhejiang Province refers to the vast mountainous area to the south of Jinqu Basin and the Jiaojiang River. It is about 175 km long from north to south and 210 km wide from east to west. It is mainly composed of Xianxia Ridge, Donggong Mountain, Dayang Mountain and Kuocang Mountain. Lishui City, which is located in the southeast of the mountainous area in southern Zhejiang, has a subtropical monsoon climate, and is close to the East China Sea in the east. Therefore, it is greatly affected by the ocean, and has a relatively obvious subtropical marine monsoon climate. On the whole, it is characterized by four distinct seasons, warm winter and early spring, abundant precipitation, synchronous rain and heat, vertical climate and diverse types. In terms of terrain, it has more middle mountains and hills, with a more significant mountainous three-dimensional climate. Its forest coverage is as high as 80%. The population density of towns in Lishui is small, and the forest resources are rich. However, the fire prevention awareness of people is not strong in the period of fire prevention, so that man-made forest fires often occur.

In this paper, a fire prevention concept with the forecast and early warning of forest fire danger weather ratings in townships as the starting point, satellite real-time observation of fire spots, monitoring of the Internet of Things and other high-tech technologies as an effective means, and strengthening forest fire prevention equipment and personnel in townships as a guarantee, and fire emergency treatment in townships as a goal was established, and the establishment of forest fire prevention and emergency command system in each township in Lishui was discussed to effectively implement and protect ecological resources. It is of great significance to improve the ecological environment, promote social and economic development, safeguard the forestry production and even the safety of people's lives and property, and also provides model basis and theoretical reference for the government and fire prevention departments in the work of forest fire prevention and extinguishing.

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1 Forecast and early warning of forest fire danger weather ratings in townships

The forecast of forest fire danger weather ratings is the first line of defense against forest fires, and meteorological departments can use short-term and medium-term weather forecast to predict future weather trends in the next few days and even more than ten days, especially for temperature and precipitation forecast.

The factors affecting the forecast of forest fire danger weather ratings include fire sources, meteorological factors, forest characteristics, geographical topography and social factors, among which meteorological factors are important external environmental factors affecting forest fires, and have the biggest relative change. The main meteorological factors influencing forest fire danger include air temperature, daily precipitation, daily relative humidity, wind direction and power. At present, meteorological grid forecast data can be used to estimate forest fire danger weather ratings according to the past data of precipitation and temperature. Sky engine data can be retrieved by adopting php + html (one is text markup language, and the other is hypertext markup language) language development and using php. In addition, the meteorological data of the future weather is obtained on the meteorological Intranet FTP through Python programming software, and related calculations are carried out. At the same time, jpgraph chart library is called to plot the operation results. Finally, html is used to make a foreground display of related results. Because the current meteorological grid forecast data has been accurate to the village level, the forecast model can be established based on the national standard *Forest Fire Danger Weather Ratings* (GB/T 36743 – 2018)[6], and it is composed of five meteorological factors, namely daily maximum temperature, daily minimum relative humidity, continuous precipitation free days, daily maximum wind speed, and daily precipitation. The longest forecast time can reach one week, and the data can be precise to each township.

2 Combination of satellite real-time observation of fire spots and monitoring of the Internet of Things

Satellite remote sensing monitoring of fire information has been gradually promoted and applied since the 1980s[7-12], and satellite remote sensing technology has been applied and developed after a massive forest fire happened in the Greater Khingan Mountains in 1987. By the beginning of the 21st century, China had established a fire satellite monitoring service system based on satellite data with medium and low spatial resolution (250 or 1 000 m). Gaofen-6 satellite was officially put into use in March 2019, and has the characteristics of high resolution (8 – 16 m), wide coverage and high quality, which is of great historical significance to improve satellite remote sensing monitoring of fire situation. GaofEN-6 satellite has the ability to reflect the information of smoke areas and burned areas formed by the burning of vegetation such as forests and grasslands, which can effectively improve the monitoring accuracy and forecasting service ability of forest fires by satellite remote sensing.

According to the national standard the *Method of Fire Monitoring by Satellite Remote Sensing—Part* 1: *General* (QX/T 344.1 – 2016), the technical process of fire monitoring by satellite remote sensing mainly includes data preparation, data preprocessing, fire monitoring, and report writing (Fig. 1).

Data preparation: Data can be quickly obtained from the fire information released by the fire monitoring system of the National Satellite Meteorological Center, and the required Fengyun satellite data or products can be downloaded through the resource pool, Fengyun meteorological satellite user utilization station or CIMISS system. Vector data such as administrative divisions and water systems, as well as land cover data are also obtained.

Since the new century, forest fire monitoring technology based on the concept of the Internet of Things (5G technology) has also been booming[13-15]. At present, forest fire monitoring technology system mainly consists of monitoring equipment, processing equipment and display equipment. Monitoring equipment mainly includes all kinds of intelligent sensors, drones, high-definition infrared cameras and other equipment as well as all kinds of intelligent equipment that can be supported. 5G communication technology is used to conduct regular inspection, analysis, and monitoring, and resource information is integrated in each forest area of responsibility areas in each township. Processing equipment plays a core role in the whole system model, and the processing layer combines multiple sensor data fusion technologies, various kinds of updatable algorithm libraries, cloud computing technology, and the whole industrial chain basic database. Display equipment means using various types of monitoring data provided by the monitoring layer or integrated information data that simulates reality to achieve fast and accurate intelligent decisions through a series of model processing and analysis. Besides, it is needed to actively improve the early warning and monitoring capability of forest fires, and strengthen the construction of "forest wisdom eye" digital intelligent control system for fire prevention.

3 Strengthening the construction of fire prevention facilities and equipment and personnel in townships

Lishui is known as the "green valley of Zhejiang", and there are 3 573 mountain peaks with an elevation of above 1 000 m. By the end of 2022, there are 53 towns (1 She township), 90 townships (6 She townships) and 30 streets in the city. Many mountainous towns are far away from urban areas, and forest areas are relatively remote compared with the urban areas. Once a forest fire occurs, it will cause great obstacles to the work of fire prevention and extinguishing. The county (city) fire rescue team cannot arrive at the scene of the fire in a short period of time (one hour, may be longer), and cannot control the fire in the first time, which greatly delays the control of the forest fire. Therefore, it is

necessary to control forest fires in townships in the first time. Higher requirements are put forward for the township fire prevention facilities and personnel of counties and cities in Lishui. It is urgent to improve and expand the comprehensive fire emergency team of counties and towns in Lishui. The establishment of fire fighting forces with township trained professional fire fighting forces as the main body, armed police forces, county fire rescue agencies and other support forces as auxiliary forces, and social rescue forces as a supplement is the development goal of forest fire fighting emergency team in Lishui City in the future.

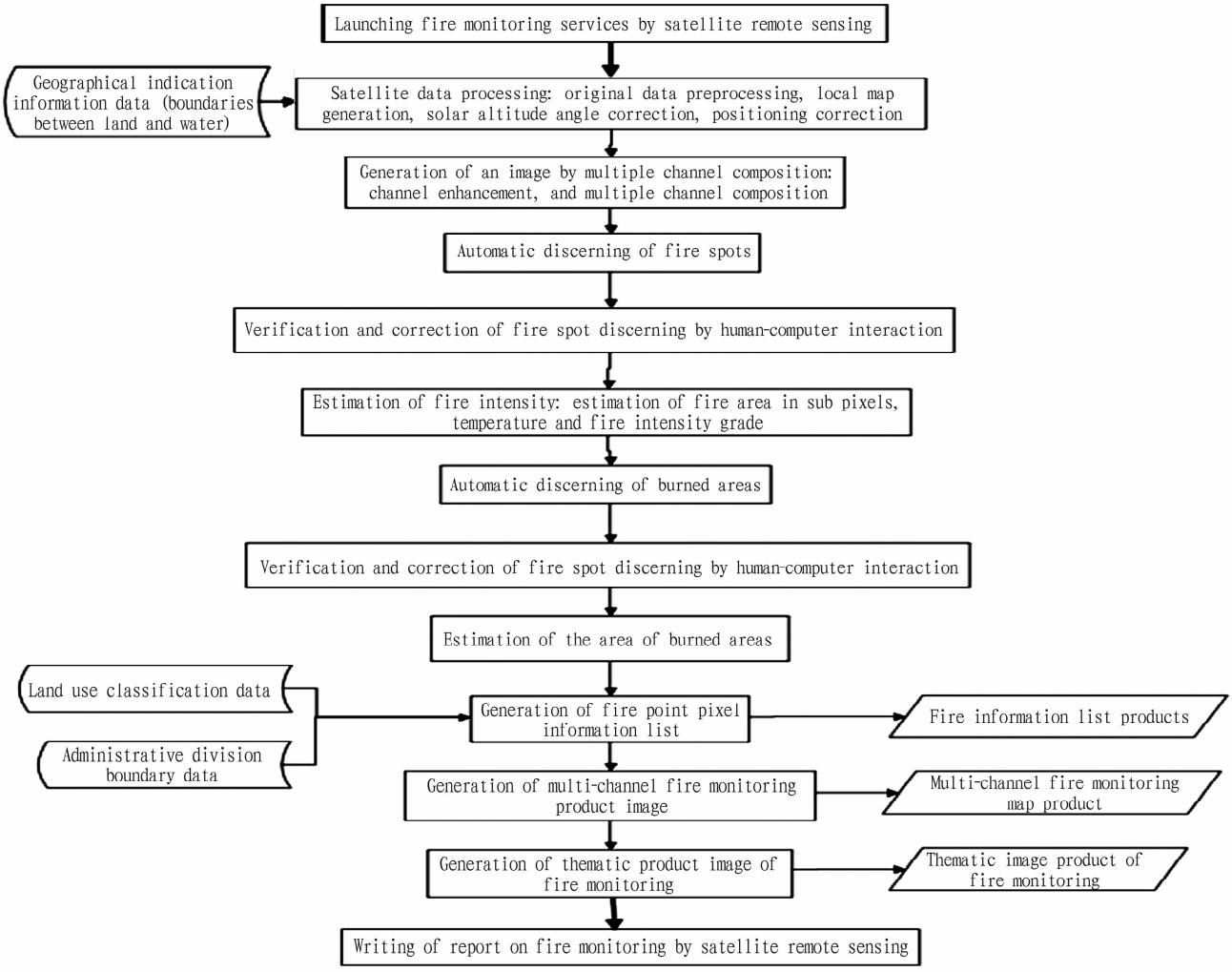

Fig. 1 Technical process of fire monitoring and evaluation by satellite remote sensing

3.1 Strengthening the investment of fire prevention and extinguishing equipment and improving fire prevention and extinguishing infrastructure Firstly, each county (city, and township) government should increase the capital investment in the fire prevention and extinguishing equipment of comprehensive emergency response teams for fire fighting in townships, and gradually improve the construction of fire prevention and extinguishing infrastructure in townships according to the weak links in the construction of fire prevention and extinguishing infrastructure, and constantly improve the emergency response ability of forest fire prevention and extinguishing infrastructure in townships. At the same time, comprehensive emergency response teams for fire fighting in townships need to regularly inspect fire prevention and extinguishing infrastructure and water supply pipelines, formulate maintenance plans, and strive to improve the response ability to forest fires. Secondly, it is necessary to continuously optimize the fire prevention and extinguishing technology, and establish a perfect intelligent fire prevention system. Township governments should pay attention to the intelligence of the fire extinguishing equipment of emergency teams, and strengthen fire monitoring. Meanwhile, it is necessary to increase efforts to purchase all kinds of fire prevention equipment with strong practicality, simple operation, high fire extinguishing performance to adapt to the development of localized fire prevention, such as the purchase of water pumps, chainsaws, wind fire extinguishers and other equipment. Besides, special personnel should effectively manage, regularly maintain and repair all kinds of equipment to ensure the normal functions of the equipment, and safety drills for fire prevention and extinguishing should be regularly carried out to test its value in the process of actual combat application.

3.2 Consolidating the comprehensive quality of township semi-professional fire prevention and extinguishing personnel, and implementing the construction of comprehensive emergency response teams for fire fighting in townships Professional fire fighting personnel are the most important guarantee force for forest fire fighting in townships[16-21]. Due to Lishui's unique mountainous terrain, many townships and forests are far from the county seat. Armed police forces and county fire rescue agencies located in urban areas can only serve as backup support forces, while comprehensive emergency teams for fire fighting in townships are the first line of defense to deal with forest fires in townships, so strengthening the professional training of fire prevention and extinguishing personnel in townships is the basic goal of implementing the construction of comprehensive emergency response teams for fire fighting in townships. At present, comprehensive emergency response teams for fire fighting in townships mainly have the following problems: there are fewer professionals for fire fighting in the teams, and the first line fire fighting personnel lack professional fire fighting knowledge and skills; the aging of the teams is high, and the number of personnel is relatively small, so that the comprehensive strength of comprehensive emergency response teams for fire fighting in townships is weak, and they cannot effectively deal with sudden forest fires. In view of the problems in the construction of comprehensive emergency response teams for fire fighting in townships, the professionalization, standardization and modernization construction of emergency response teams for fire fighting is conducted to comprehensively improve the effectiveness of fire prevention and extinguishing work in townships, and the main countermeasures are as follows. Firstly, the professional construction of fire prevention and extinguishing teams in townships should be strengthened. Townships can inject fresh professional blood into the existing team through professional talent recruitment, and can also invite fire experts to carry out professional guidance and teaching regularly in various townships to form a long-term mechanism. Meanwhile, the promotion of professional quality of forest rangers in fire prevention should be strengthened to constantly expand the comprehensive quality of fire prevention teams in townships. Secondly, the standardized construction of fire prevention teams in townships should be improved. In order to build an excellent fire prevention team with high professional quality, reasonable system and process management mode are indispensable. It is necessary to actively explore the township emergency management office, optimize the management mode, formulate the team organization and management system, training mechanism and forest fire fighting actual operation manual, and promote the construction of forest fire prevention and extinguishing teams in villages. Each forest-involved village group should build an emergency assault team with a reasonable age structure of about 10 people according to the combination of defense areas. The most basic emergency rescue equipment and personal protective equipment should be equipped with, including disposal and rescue of forest fires and other emergencies and disasters. In addition, it is needed to strengthen the construction of forest ranger teams, further strengthen the management of forest rangers, clarify the duties of forest rangers, strengthen the awareness of fire safety responsibility, promote the improvement of the forest grid management system, and implement the treatment of forest rangers.

4 Establishing a command system for rapid emergency response by cities, counties and townships

The Lishui Headquarter For Forest Fire Prevention, which is the central brain of emergency response to the city's forest fire prevention events, is responsible for organizing, coordinating and guiding the city's forest fire prevention work. It is necessary to give full play to the leading role of the headquarters, strengthen its functions of organization, coordination, guidance and supervision, improve the division of labor and cooperation mechanism of departments, and promote the implementation of various responsibilities at all levels. Firstly, the hierarchical responsibility for territorial management should be adhered to. In accordance with the requirements of "basic coordination between the upper and lower levels", each county (city, and district) and development zone shall set up a forest fire prevention command organ to be responsible for organizing, coordinating and guiding forest fire prevention work in its own administrative area, and fully implement the administrative head responsibility system, the "forest chief system" and the "forest chief police system" for forest fire prevention. One county leader is responsible for one township (street), and one township (street) leader is responsible for one village. One village cadre or party member is responsible for one forest area. It is seen that the responsibilities and division of labor are clear. Secondly, the regulatory responsibilities of functional departments should be implemented. The Municipal Emergency Management Bureau (Municipal Forest Prevention Office) assists the Municipal Party Committee and municipal government to organize major forest fire emergency response work, strengthens departmental linkage, makes efficient coordination, enhances work force, and comprehensively guides the forest fire prevention and control work of counties (cities, districts), development zones and relevant departments in accordance with the principle of hierarchical responsibility. Meanwhile, it should carry out comprehensive monitoring and early warning work of forest fires, and be responsible for organizing, guiding and coordinating forest fire fighting and emergency rescue work. County and township forest fire prevention command organs and county-level member units have detailed the division of tasks, clarified the connection relationship, and accelerated the formation of a top-down, overall coordination and linkage work pattern. Thirdly, the emergency command work of personnel and equipment should be done. According to the needs of forest fire response, the territorial fire fighting forces should be mobilized first, and the neighboring forces should be used as reinforcements. When local fire fighting teams are mobilized from other counties (cities, and districts) and development zones to reinforce fire fighting, the municipal forest prevention and control director shall coordinate, and the forest fire prevention and control command agency of the call-out county shall organize the implementation, while the call-in county shall be responsible for docking and related protection. Fourthly, forest fire prevention headquarters at all

levels should adhere to the implementation of the basic principles of forest fire suppression in the actual work, and strive to eliminate forest fires in the initial stage and before the disaster. Besides, it is needed to give full play to the advantages of quick emergency response and early fire control of semi-professional fire prevention teams in townships, and try to effectively control and extinguish fires in the early stage.

5 Conclusions and discussion

(1) Rich forest resources in Lishui City are not only an important local ecosystem with important biodiversity and environmental functions, but also a kind of social and cultural tourism resources. The protection of forest resources plays an indispensable role in protecting the ecological environment of Lishui City and improving the local social and economic development. Forest fire danger is characterized by strong sudden occurrence, great destructiveness, wide occurrence area, difficult to determine fire sources and difficult to fight and dispose. The establishment of fire fighting forces with a township semi-professional fire fighting team as the leading force, armed police forces, county fire rescue agencies and other support forces as auxiliary forces, and social rescue forces as a supplement is the development trend of forest fire fighting emergency team in Lishui City in the future.

(2) A fire prevention concept with the forecast and early warning of forest fire danger weather ratings in townships as the starting point, satellite real-time observation of fire spots, monitoring of the Internet of Things and other high-tech technologies as an effective means, strengthening forest fire prevention equipment and personnel in townships as a guarantee, and fire emergency treatment in townships as a goal was established. Based on the command system of forest fire prevention and fire fighting headquarters at all levels in Lishui City, the basic principles of forest fire fighting should be implemented into the actual fire prevention and fire fighting work to eliminate forest fires in time at the initial stage and before the disaster.

(3) During the fire prevention period, strict control of fire sources is one of the most effective measures to reduce forest fires in Lishui City. After the meteorological department releases high-level (orange and red) forest fire danger weather ratings, all townships, forest areas, village committees and forest rangers should strengthen the publicity of fire prevention work in the responsibility area, and forest rangers should strengthen patrol work. Fires should be reported to the local forest fire prevention headquarters at the first time.

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