

Flood Decision Support System with Emerged Multiple Data Resources and Technologies

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Abstract. *Flood is one of the worse natural disasters that can cause losses of lives and damage large number of properties and areas worldwide. The crucial factor that leads to serious flood is the lack of data and information of rain in terms of time duration, volume of rainfall, and locations. Therefore, it is reasonable to develop the tools or systems to monitor the situation of rain in order to reduce the losses and severe conditions. This research proposes the flood decision support system using emerged multiple data resources and technologies. The technologies regarding flood management of both structural and non-structural measures were emerged with available technologies and scientific data and information, which would provide a better and faster way for analyzing and evaluating the flood situation. This monitoring information would help for the decision of the further actions for both government and local organizations to effectively reduce the risk of damage that could be caused by the flood.*

Keywords:

Flood, decision support system, rainfall, water management, flood technologies

1. Introduction

Thailand locates in the southwest monsoon and northeast typhoon; therefore, the country has high potential of heavy rainfall varies dependent by seasons and regions. During the rainy season, Thailand always encounters flood problems caused by heavy rains. These problems consequently affects several severe problems and damages on communities and agricultural areas along both sides of the rivers or even the large flat areas; especially, during August-October of every year. The flood also causes huge impacts on economy, society, tourism and environment, which would require a large amount of money and time to recover. In fact, some of the damages and losses, such as the losses of family members, properties and belongings, would be hard to recover and improve [1].

Regarding rainfall information, the current status of the temperature is also different in each particular season and location. The change of rainfall and temperature are then affect the utilization and patterns of the lands for both residential, industrials or agricultures, which are thus have changed considerably for these recent decades compared to the past. The physical and biological living things are consequentially changed due to the results of abnormal patterns and dynamic changes of the rainfall and temperature. In addition, the natural parts that have ever helped on holding or draining the large amount of water have also changed. This leads to an even more dangerous and severe effects of the flood nowadays compared to the past, which would require a fast response to overcome and solve this problem; otherwise, losses and damages will even more and more in near future.

Therefore, emerging available scientific knowledge and available technologies such as the meteorology, hydrology and engineering would be useful for both monitoring and eliminating severe caused from the flood; specifically, evaluation of possible risks of flood occurrences and assessment of flood situations, which would be necessary for the safety policy for the government and the local management authorities. This issue leads the authors to study the flood situations in Thailand, then searching for possible data resources and information, as well as, currently available technologies which could be used for creating the systems that could be used to monitor and manage the risks and issues related to the flood conditions.

2. Research Objectives

This research therefore aims to study the possibility of emerging data resources and available technologies together to monitor and reduce the severe of the flood. The focused area of study was the whole locations of the Thailand kingdom.

3. Methodology

3.1 Flood in Thailand

Flood history in Thailand, in 2005, 2006, 2010 and 2011, Thailand has encountered 13 times of severe floods in almost every province. Nevertheless, the most severe flood in the Mekong region and Chao Phraya River Basin occurred 8 times in the years 1975, 1983, 1995, 2002, 2005, 2006, 2010, and 2011. Those caused great damages to lives, property as well as the country economics. For example, the 2011 flood caused economic damages of 1,440,000 million baht (approximate 41,143 million USD), which was a very high loss cost compared to others [2].

According to the Department of Disaster Prevention and Mitigation, the moderate risk areas (4-5 times in 9 years) and high risk areas (more than 5 times in 9 years) are prevailing in the area of 1.6 million hectares. Furthermore, the landslide risk area is found in 6,042 villages throughout the country. The major reasons of landslide are heavy rainfall, deforestation in watershed area and physical condition of the river basin with steep mountains [2].

3.2 Decision Support System

The development for Decision Support System (DSS) is a part of National Strategy for Thailand's Water Resources Management especially on Administrative Management with creating purposes as follows:

- 1) Create a national water and infrastructure database that efficiently collects and connects information from all related agencies.
- 2) Create a system for following up, monitoring and predicting normal water situation, and deciding, addressing and mitigating flood and drought in crisis integrative situation, and
- 3) Create a process for guiding water development, conservation and maintenance systematically and continuously.

3.3 The Development of Decision Support System

The development of decision support system includes 4 sub-strategies as follows:

- 1) Infrastructure development (I: Infrastructure): The existing database is improved to be more precisely. Rain information is enhanced and covered areas, which can be expanded and linked to information center. Information service is also improved and information system standard is set up.

- 2) The DSS development for normal situation (N: Normal) A model for climate analysis and prediction is improved both short and seasonal periods. Its water situation prediction is more efficient, detailed and comprehensive, throughout Thailand. Modelling calculation is linked to information center in supporting the dam, water allocation and crop planning management and revise monthly water allocation.

- 3) The DSS development for crisis situation (C: Crisis) Crisis management in the levels of district, province and region is responsive to a situation by a backup of precise immediate climate, water prediction, and scenario simulation of risk and crisis. This helps in creating options in handling, managing and early warning a crisis in advance as well as improving disaster relief.

- 4) The DSS support/preservation/maintenance system (D: Development) This involves infrastructural exploration, maintenance and improvement of planning, risk and trend evaluation, budget allocation, and monitoring and evaluation of information that disseminates from central agencies to local agencies and vice versa for the sake of analysis and decision.

3.4 Water Resource Management

Water resource management importance needs [3] the precise information, efficient human resources and agencies which the DSS details are as follows:

- 1) Mapping system: Currently, the most precise data is at meter level. This particularly causes ineffective flood management in flood plain. A limitation in a field survey and a real time report constrains a quick responsive planning to address a crisis. For an effective and continuous operation in a time of crisis, it is necessary to do a survey using Global Navigation Satellite System (GNSS), and high resolution of Thailand Geoid Model must be developed [4]. All these may support a quick effective survey with a vertical deviation value not exceeding 30 centimeters in all areas. This plan has invested in 80 GNSS stations and renovated 9 old stations of Department of Public Works and Town Planning from GPS to GNSS. It has improved accuracy and baseline map details and collection and service of online GPS data.

- 2) Telemetering station: A telemetering station project involves improvement and replacement of old stations with new equipment. Some stations will be equipped with more precise radar technology with ± 2 mm deviation in all ranges. This reduced frequency and cost of maintenance from 500,000-300,000 Baht per one station to approximately 250,000 Baht per one. Moreover, a system for measuring water quality will be installed, so that automatic water quality measuring stations will increase from 116 to 319 stations.

3) Water data inventory: Data connections will be expanded from 13 agencies to 30 agencies. A full data service responsible by Hydro Agro Informatics Institute and related agencies including website, mobile devices, data network, and enhancement of system and maintenance will be developed to become national water database.

4) Modelling system: it includes climate, water situation (run-off and flood) and quality prediction.

4.1 Modelling for climate predictions consist of investment in highly efficient computer system for predicting short, seasonal and long term climates. The system can predict the precipitation with spatial resolution not less than 3x3 km², which enhances the efficiency in monitoring climate and increases period of early climate prediction.

4.2 At present, modelling for forecasting water situation (run-off and flood) and water quality is covering all main river basins. Water quality model is still not capable for a real-time forecasting. Baseline data should be updated by connecting gauging data and modelling results to data center to increase efficiency, especially in a crisis, which needs forecasting, monitoring and scenarios for decision making support.

5) Analysis and monitoring system: This emphasizes on increasing efficiency of analysis and monitoring system for reporting water situation of related agencies. Climate prediction center will be established for 24 hour surveillance and monitoring using international standard. The Bangkok Flood Prevention Center will be improved and promoted as a model of urban water resource management.

6) Disaster Management System: The system is establishing for a crisis management in response to disasters especially flood and drought, preparation and early warning before a crisis occurs. This helps in sending a disaster relief team quickly to the affected areas. The action plan includes war room establishment, linking all data using similar standards. So, disaster warning networks are coordinated for immediate warning. A communication system is used for an early warning system in order to conduct a comprehensive coverage. Disaster area data is collected to precisely predict urgent events provides the system, which helps to analyze disaster relief and Information and Communications Technology (ICT) for necessary relief items and equipment provision.

7) Decision making system: Currently, its policy decision maker is depending on data from several sub-systems without integration. It is necessary to have an instrument in managing integrative data in a form of Business Intelligence and DSS. These systems can classify data according to scenarios, covering all high potential situations, and other baseline data around affected areas and prompted the decision making and solution of a crisis efficiently.

8) Knowledge system: the system aims to collect law and regulations related to water management including baseline data survey to provide systematic and area-based indicators. Other knowledge can be unlimited and added up to this system. Research outputs in water management are connected to the system so they can be quickly retrieved and searched to use the budget and socio-economic planning.

9) Research system: an analysis and research process, which creates knowledge in water management especially standard, telemetering, data communication networks and data management system, will be set up. The system emphasizes on capability of equipment and standard in data collection with enables co-utilization. Also, reference values have similar standard when evaluating normal and crisis situation can be predicted.

4. Flood Event in Thailand

In 2016, the majority weather of Thailand was warmer with more rain than usual annual rainfall [5]-[8] averaged over the country with 1,718 mm was roughly 130 mm (8%) above the 1981-2010 normal while annual mean temperature of 28.0°C (about 1°C above normal) was the warmest year in Thailand according to 66 years of records and ranks first together with 1998. The mean temperature was above normal especially April and May which were 2.2 and 1.8°C above normal, respectively. The maximum temperature reached the new all-time record in several areas. Precipitation in Thailand was affected by 6 tropical storms or cyclones of which 2 struck Thailand while still classified as storms or tropical depressions, namely the tropical storm RAI that moved into Ubon Ratchathani and Amnat Charoen provinces on 13th September and the tropical storm AERE that moved into Mukdahan and Nakhon Phanom provinces on 14th October. Besides that, rainfall in Thailand was indirectly affected by tropical depressions such as the tropical storm MIRENAE in late July coming from middle Vietnam in late June, DIANMU in middle August and the tropical depression in Cambodia in early November.

Significant flood events developed in August due to the influence of DIANMU, a tropical storm which occurred during 12-23 August 2016. These events caused heavy rainfall in the north and north-eastern regions. In the wake of DIANMU, Thailand obtained heavy to very heavy rainfall in some areas in the North and Northwest. Maximum daily rainfall of 190 mm was observed at Pua in Nan province on 14 August. Flash floods occurred at Mae Hong Son province on 13 August, at Chiang Rai province on 14 August, at Payao, Nan and Tak provinces on 15 August.

The typhoon RAI in September caused heavy rainfall in the lower part of the North and Northeastern regions during 13-14 September 2016 [6]. RAI moved across Laos and was downgraded to a tropical depression before entering Thailand at the adjacent area of Ubon Ratchathani

and Amnat Chareon provinces. It moved past Yasothorn, Roi Et and Kalasin provinces and was downgraded into an active low pressure cell while located at Roi Et, Kalasin and Mahasarakham provinces before covering middle north-eastern and lower northern parts. These conditions brought abundant rainfall to upper Thailand for almost the whole period. The heaviest daily rainfall was recorded as being 248 millimeters at Phu Kradung National Park in Loei province on September 11. Flash floods occurred at Loei province on September 13, at Mae Hong Son, Chiang Mai, Phayao and Phrae provinces on 18 September and at Tak province on 19 September. Sukhothai province experienced overtopping river banks on 15 September.

4.1 Impacts of floods 2015

The Significant flood effects of floods occurred in September, 2015 from the influence of “VAMCO”, a Typhoon storm. These events caused heavy rainfall in Nakorn Ratchasima province [5]-[7], as shown in Fig.1.



Fig. 1 Flood events in Nakorn Ratchasima province, September, 2015 [8]

4.2 Impacts of floods 2016

The flood event in the wake of tropical storm DIANMU during 14-20 August, 2016 affected the Nan and Chiang Rai provinces [5]-[6], as show in Fig.2. While during 13-14 September in the same year, the northeast of Thailand; especially, in Khon Kean and Ubol Ratchathani provinces, was affected by heavy rainfall exceeding the drainage systems’ capacities in the cities, as shown in Fig. 3. These flood events led the government, local administrations, as well as private organization to realize the importance of developing the effective system for

decision making in order to prevent the serious losses and damages. Therefore, most provinces across Thailand kingdom have started developing the DSS.



Fig. 2 Flood events in Nan and Chiang Rai provinces, August 2016 [8]



Fig. 3 Floods in Khon Kean and Ubolratchathani provinces, September 2016 [8]

5. Available Flood Technologies

Since 2011 floods; in response, the Royal Thai Government (RTG) drafted a Master Plan on flood management, after which it established the National Water Resources and Flood Policy Committee (NWFPC) and the Water and Flood Management Commission (WFMC). These bodies formulate policies, approve investment projects, and monitor the implementation and impact of these projects. Besides these national committees, there are three major ministerial departments involved in flood management. The Royal Irrigation Department (RID), under the Ministry of Agriculture and Cooperatives, plays a significant role in constructing and maintaining waterways and flood protection systems. The Department of Disaster Prevention and Mitigation, Ministry of Interior, is responsible for the coordination during disasters and recovery management. The Department of Water Resources (DWR), Ministry of Environment and National Resources, monitors flood mitigation in the 25 river basins. Many other departments have specific tasks to prevent, oversee and manage floods.

In terms of flood management in Thailand still have many agencies to respond and various technologies to cope with floods as some descriptions as below.

5.1 Department of Disaster Prevention and Mitigation

The Department of Disaster Prevention and Mitigation (DDPM) has developed a disaster report system available at <http://www.disaster.go.th> (Fig. 4). Users can search for any types of disaster, time period and area. It is very useful to look back at the history of natural disasters especially floods that occurred in the country.



Fig. 4 Website of the Department of Disaster Prevention and Mitigation [9]

5.2 Department of Water Resources

The Department of Water Resources (DWR) has established under the Bureaucratic Reform Act 2002 under the Ministry of Natural Resources and Environment and has

defined standards and transfers technology of water resources at both national and basin levels, to achieve sustainable water resources management. One of the important missions of the DWR is to further develop knowledge base of floods and landslide disasters in order to enhance the readiness of communities in disaster prone areas to cope with floods. For that reason, DWR has installed an early warning system (EWS) (see Fig.5). The early warning for the flood plain areas is under the supervision of the Water Crisis Prevention Centre within DWR and is divided into 2 parts:

Part 1: Establishment of a telemetry system that is able to monitor current states in remote areas by analyzing rainfall, water levels, geological conditions and other governing factors by means of modelling and to present results thereof at www.mekhala.dwr.go.th/. The purpose is to forecast and detect critical situations to enhance lead time and response actions.

Part 2: Installation of a closed-circuit television (CCTV) and remote control system for monitoring of flood related states (see Fig.6). Data received from the system could be used to support decision-making forecasts.

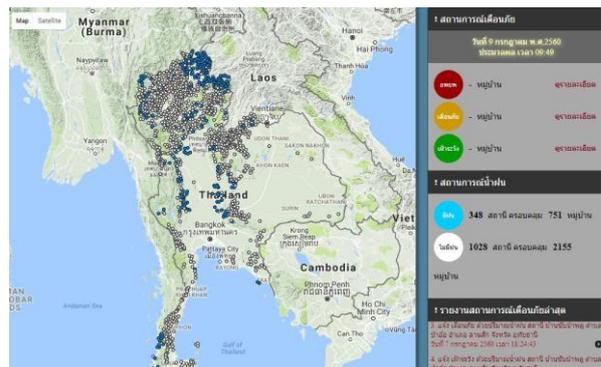


Fig. 5 Early Warning Systems website of DWR [10]



Fig. 6 DWR-Telemetry Systems website for flood plain area [11]

Moreover, Information of the Khong-Chi-Mun river basin, which is a part of Lower Mekong Basin (LMB) can be accessed at <http://tele-khongchemun.dwr.go.th/> by DWR as show in Fig.7-9.

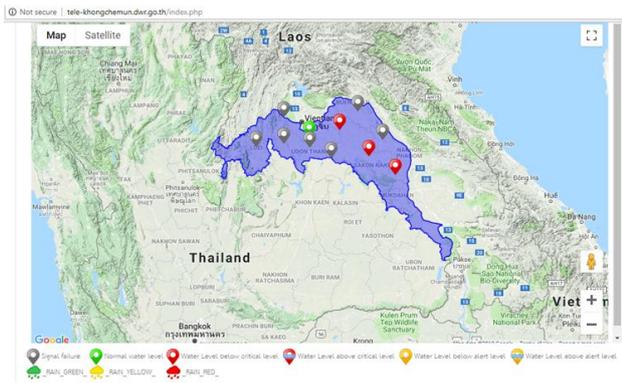


Fig. 7 Telemetry system for Khong basin [12]

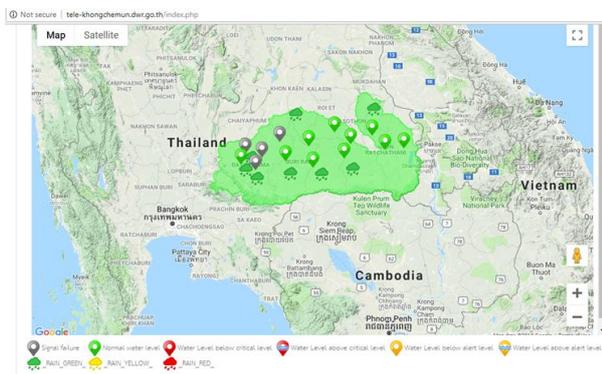


Fig. 8 Telemetry system for Chi basin [13]

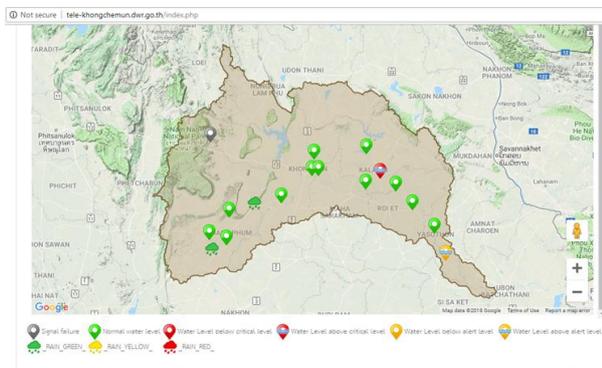


Fig. 9 Telemetry system for Mun basin [14]

5.3 The Royal Irrigation Department

Duties and responsibilities of the Royal Irrigation Department (RID) according to the Ministerial Regulation Organizing the Royal Irrigation Department, Ministry of Agriculture and Cooperative includes:

- 1) Implementation, controlling, distributing, draining or allocating water for agricultural, energy, household consumption or industrial purposes under irrigation laws, ditch and dike laws and other related laws

- 2) Implementation of activities related to prevention of damages from water; safety of dams and appurtenant structures; navigation in commanded areas and other related activities that may not be specified in annual planning

- 3) Implementation of land consolidation for agriculture under the Agricultural Land Consolidation Act

- 4) Implementation of other activities designated by laws or properly assigned by Cabinet or Minister

The RID’s objectives and framework consist of (1) Water resources development and increase of irrigated area, (2) Integrated water management, and (3) Water hazards prevention and mitigation as the department’s missions. Therefore, The RID has also developed a telemetry and early warning system for location under the responsibility of RID as shown in Fig.10.

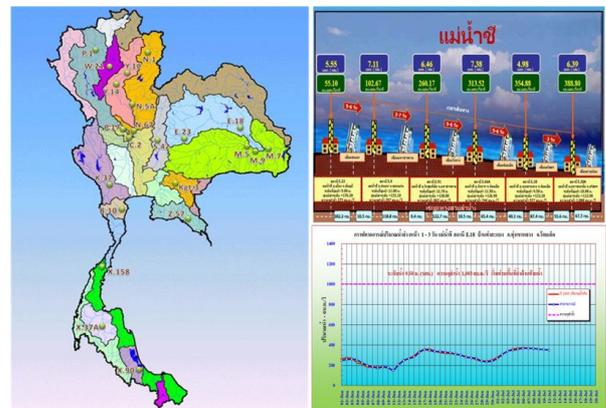


Fig. 10 RID telemetry System [15]

5.4 Geo-Informatics and Space Technology Development Agency

The Geo-Informatics and Space Technology Development Agency (GISTDA) is a Thai space agency and space research organization. It is responsible for remote sensing and technology development satellites. It is led by Thailand's Minister of Science and Technology. GISTDA has established the Thailand Flood, Drought and Rainfall Monitoring System providing both real time data and historic data of flood and drought illustrated in Fig.11.

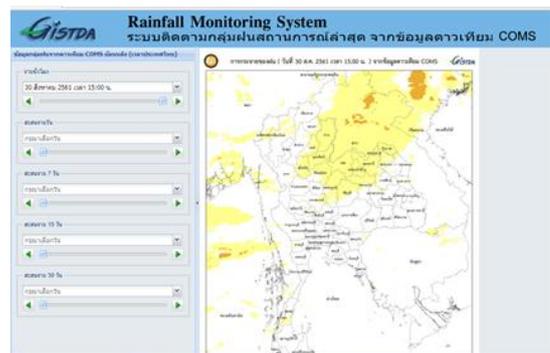


Fig. 11 Thailand Rainfall Monitoring System by GISTDA [16]

5.5 Hydro and Agro Informatics Institute

The Hydro and Agro Informatics Institute (HAI) is a public organization under the Ministry of Science and Technology, which focus on developing and applying sciences and information technology to better support agricultural and water resource management [17] (Fig.12).



Fig. 12 HAI Rainfall and Telemetry system [17]

Another field of work HAI is involved in is Community Water-Related Disaster Risk Reduction. HAI develops and provides best practices guidelines for communities on science and technology to address disaster risks, natural resource management and sustainable agriculture can be used. The practices and case studies present an integrated approach that aim at building resilience and sustainable livelihoods. The case studies also demonstrate the Sendai Framework, the 2030 Agenda for Sustainable Development (or Sustainable Development Goals) and Climate Change Agreement can be implemented coherently at a local level.

5.6 Electricity Generating Authority of Thailand

The Electricity Generating Authority of Thailand (EGAT) is Thailand’s leading state-owned power utility under the ministry of energy, which is responsible for electric power generation and transmission for the whole country. As the largest power producer in Thailand, EGAT operates 25 hydropower plants located across the country.

EGAT has developed and established a telemetry system to monitor all hydropower plants that is important for water management, including water quality and stream gauging and regulating functions. Monitoring data is published at EGAT’s website at <http://watertele.egat.co.th/PakMun/> as shown in Fig.13 for the Mun River, a tributary of the Mekong.

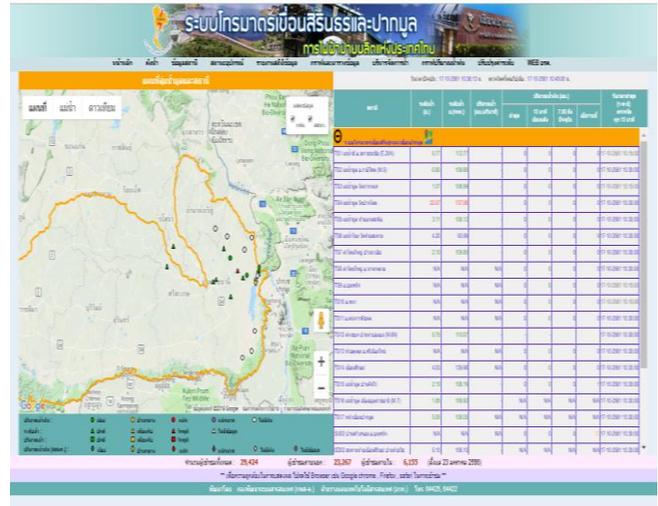


Fig. 13 EGAT Telemetry systems [18]

6. Conclusions

Thailand’s flood decision support system (DSS) and management system could be efficient success depending on the clear policy and working office management. In order to achieve that diversity of data resources and multiple technologies to cooperate with flood DSS should be used with suitable locations and times. Big data of methodology, hydrology, and river basin characteristics should be comprehensive with a compatible platform for the DSS. There are several measurement results for the managers, planners, and flood planning technologies. The goal of the DSS of flood management consists of 3 agencies such as Department of Water Resources, which under the Ministry of Natural Resources and Environment, The Royal Irrigation Department, Ministry of Agriculture and Cooperative, Department of Disaster Prevention and Mitigation, and others agencies.

Ministry of Natural Resources and Environment is following flood situation 25 basins. The Royal Irrigation Department aimed to draining or allocating water for flood control. Department of Disaster Prevention and Mitigation provide data of disaster, time period, and area, those are natural disasters especially floods in the country.

Agencies of water management, measurement, and technology are good for government, but non-covering. Furthermore, the suggestions for Thailand government should develop and provide the open data resources to the private sectors. The data of flood situations would early warn the local people in the case of flood occurrence; giving them the time for preparation, adaptation or development of networks, which could be faster way to deliver the information of flood situations. In particular, They could be helped and the losses and damages could be also reduced.

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Biography



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