THE TRANSITION OF SABO WORKS FOR DISASTER MITIGATION IN JAPAN

Masao Okamoto[1*]

INTRODUCTION

Ten years have passed since the beginning of the 21st century. During that time, a huge number of large-scale natural disasters occurred in various parts of the world **(Table 1)**.

Table 1. Major natural disasters that occurred in the world from 2001 to 2010 (As of March 3)

Date (m/y)	Region	Country	Disaster		Damage	
			Type	Name	Killed	Est. Damage (US$ Million)
03/2004	Eastern Africa	Madagascar	Tropical cyclone	Galifo	363	250
08/2006	Middle Africa	Ethiopia	Flash flood		498	3
05/2003	Northern Africa	Algeria	Earthquake		2,266	5,000
01/2010	Caribbean	Haiti	Earthquake		230,000	
09/2004		Haiti	Tropical cyclone		2,754	50
10/2005	Central America	Guatemala	Tropical cyclone		1,513	988
08/2005	Northern America	United States	Tropical cyclone	Katrina	1,833	125,000
02/2010	Southern America	Chile	Earthquake		799	
08/2007		Peru	Earthquake		593	600
05/2008	Eastern Asia	China	Earthquake		87,476	85,000
10/2004		Japan	Earthquake		40	28,000
08/2007		Korea	General flood		610	300
08/2009		Taiwan	Tropical cyclone	Typhoon Morakot	630	250
09/2009	South Eastern Asia	Indonesia	Earthquake		1,177	2,000
05/2006		Indonesia	Earthquake		5,778	3,100
12/2004		Indonesia	Tsunami		165,708	4,452
05/2008		Myanmar	Tropical cyclone	Cyclone Nargis	138,366	4,000
02/2006		Philippines	Landslide		1,126	2
11/2004		Philippines	Tropical cyclone	Winnie	1,619	78
12/2004		Thailand	Tsunami		8,345	1,000
03/2002	South Asia	Afghanistan	Earthquake		1,000	

[1] Director General, Japan Sabo Association, 2-7-5, Hirakawac-cho, Chiyoda-ku, Tokyo, Japan (*Corresponding Author; E-mail: okamoto@sabo.or.jp)

11/2007		Bangladesh	Tropical cyclone	Sidr	4,234	2,300
12/2004		India	Tsunami		16,389	1,023
01/2001		India	Earthquake		20,005	2,623
12/2003		Iran	Earthquake		26,796	500
10/2005		Pakistan	Earthquake		73,338	5,200
12/2004		Sri Lanka	Tsunami		35,399	1,317
04/2009	Southern Europe	Italy	Earthquake		295	2,500

(Quoted from EM-DAT, Center for Research on the Epidemiology of Disasters and added data of 2010)

Last year, Taiwan suffered serious damage due to Typhoon Morakot. It is almost 20 years since our Japan Sabo Association has started Sabo technical exchange with Taiwan. As part of this relationship and with thoughtfulness from the Taiwan side, we were able to conduct a field survey at the damage site last October. Though the survey was just for a short time, the scale of the disaster observed at the site was far more than we imagined. We sincerely hope that the affected people and area will be restored to the former state as early as possible.

Photo 1. Disaster in Siaolin Village (Taiwan)

Japan is also a disaster-prone country. The land is mountainous, terrains are steep, and the geology is fragile (primary causes). Therefore, disasters are easily triggered when earthquakes, volcanic eruptions, typhoons, and heavy rains (secondary causes) hit the Japanese land. The damage is further worsened by narrow habitable areas and other man-made impacts, such as human behaviors and production activities.

Over the course of its history, our ancestors strived to protect their living base, by creating laws and rules, improving disaster prevention technologies, and taking countermeasures while confronting severe nature and sometimes encountering disasters.

Our country's narrow land is composed of small river basins. Therefore, if a large-scale disaster occurs, devastating damage spreads over the entire river basin. Sediment–related disasters are particularly serious, because their massive power causes much severe damage than other disasters.

Under such hard condition, how to manage river basins in terms of disaster prevention is extremely important in order to protect our lives and develop social economy. Without disaster prevention, we cannot achieve the development and prosperity of our country. This is the background of the disaster prevention powerhouse Japan and its national policy that puts particular emphasis on disaster prevention. We are pleased if our disaster prevention history, particularly in the area of sediment-related disasters, can provide some help when you prepare measures fit for your country's situations.

THE TRANSITION OF LAW AND SYSTEM OF SABO

The Beginning of Sabo

Tracing documents back to the origin of the idea of forest conservation in Japan leads to a notification issued in 677, that states, “Cutting and harvesting plants on Mt. Minamibuchi and Mt. Hosokawa and burning of mountains and fields in the regions surrounding the imperial capital is prohibited.” This area is located in Asuka village where was Japanese capital 1,400 years ago, Nara Prefecture **(Photo 2)**.


Photo 2. Thono river (Asuka village)

One well-known Imperial decree issued in 806 states, “On Mt. Ohi in Kadono County, Yamashiro Province, flooding of river breaks the dikes under water” and “therefore, cutting of trees on the river banks shall be prohibited.” The river mentioned here is what is currently known as the Katsura River in Kyoto Prefecture.

The purpose of the notification and decree mentioned above has been debated: They may have been for appeasing the god of the mountains who brings harm, for preventing residents from entering the mountains which were assets of the government and aristocrats, or for forbidding the cutting of trees from the viewpoint of sediment control or for preventing sediment discharges.

The origin of sabo administration can be found in an official central government document issued in 821, as a regulation on activities in forest areas, which were sediment production areas overseen by sabo administration in terms of national land management.

The document warns against depending on weirs and ponds for securing agricultural water required for paddy cultivation and instructs on preserving the mountains near rivers for securing water supply.

The Low of Mountains and Rivers

The Yodo River Basin in the Edo period (1600~1868) had a large population centered in Osaka, which was referred to as the “Kitchen of the Nation” and was prosperous with vigorous commercial and industrial activities and water-borne transportation. Economically it was the most important region for the Shogunate Government of Edo.

In 1660, the Shogunate issued a proclamation to the provinces of Yamashiro, Yamato and Iga in the Yodo River Basin prohibiting removal of waste roots and to order planting of saplings on bare mountains.

Subsequently, a set of rules were announced as a binding law: the famous “The Low of Mountains and Rivers” dated February 2, 1666. The Regulations state the following:
・In recent years, mountain plants have been dug out including their roots, which causes sediment runoff in channels that prevents water from flowing. Accordingly, from now on plants must not be dug out entirely including their roots.
・Trees on the sides of rivers near their headwaters in mountains have been decreasing.
Saplings must be planted to prevent sediment discharges.
・No new fields should be cultivated, and no bamboos, phragmites or reeds are to be grown or extrusions made along the channels or on the bank of a river that narrows its cross section.
Supplementary provision: No fields should be burned in mountains.

The regulations show that specific and strict control and management were required. In the background of this trend was Banzan Kumazawa (1619-1691), a scholar who emphasized the importance of forest conservation. Influenced by another scholar, Toju Nakae (1608-1648), during his youth, Kumazawa worked for Lord Mitsumasa Ikeda of the Okayama Domain and taught forestry and agricultural administration. In his book “Shugi Gaisho,” a compilation of his ideas, Kumazawa described that cutting down plants and digging out roots of trees in mountains would cause disasters and states that political corruption and disorder would lead to poverty of people, who would then not hesitate to cut down an excessive amount of trees for fuel, and forests would accordingly be destroyed **(Photo 3)**.

Photo 3. Portrait of Banzan Kumazawa [1)]

Yodo River Headwaters Sabo Law

At the time of the establishment of the Meiji Government in 1868, laws and institutions for forest control, etc. under the Shogunate system disappeared. The first incidence of sabo administration by the new government was the investigation for sabo works in the Kizu River Basin of the Yodo River Water System conducted under the Ministry of Civil Affairs in 1870.

In September 1873, the Meiji Government issued the so-called “Yodo River Headwaters Sabo Law” in the Ministry of Finance Additional Notification, which states that “care shall be taken to observe the Yodo River Water Source Sabo Law as per annexed paper,” for Kyoto, Osaka, Nara, Shiga, Sakai, and Mie Prefectures.

The Yodo River Headwaters Sabo Law contains eight articles:
Rule 1: Cutting of vegetation and cultivation shall be prohibited in any land concerned if privately owned. If cutting or cultivation is absolutely necessary, the provincial governor shall attend to the case by providing authorization standards with topography, etc. taken into consideration.
Rule 2: If there is any possibility of sediment runoff from fields on a slope of a spur or at a valley mouth, the provincial governor shall take preventive measures.

Rule 3: Any bare ground on a hillside shall be planted with selected vegetation. If the vegetation does not develop or take root, measures such as change of types of vegetation shall be taken.
Rule 4: Sabo works shall be implemented by taking advantage of past experience and appropriately selecting effective techniques. Further study shall be made if it does not produce tangible results. Sabo works of a scale too large for the local authorities to carry out shall be presented to the government for instructions.
Rule 5: Cost of such sabo works to which Rule 2 applies shall be appropriately funded by obligating the owner of the fields. Otherwise the cost will be covered by the national treasury according to the provisions published.
Rule 6: For the accomplishment of the purpose of this law, target areas shall be specified based on the geographical features and circumstances. Appropriate measures shall be taken including setting of a timetable of the works.
Rule 7: Areas under alternating jurisdictions in a basin shall be subject to consultation between the provincial governors concerned for defining the scope of jurisdiction. It must not be unilaterally determined.
Rule 8: Prefectures concerned with this basin shall dispatch officials for the disposal of affairs according to the geographical features of the areas in their jurisdictions.

The Law incorporates the backbone concept of Japan's sabo administration and projects including the prohibition of and restriction on disaster-inducing acts, methods of sabo works, sharing of the expense incurred division of target areas, management method, etc.

Sabo Law

The Sabo Law, which was enacted and promulgated as Law No. 29 on March 30 and went into effect on April 1, 1897, is known as one of the oldest existing laws in Japan. Article 1 states that sabo facilities shall be constructed for the purpose of sabo from a flood-control viewpoint and Article 2 provides that a designated sediment control area means the area where certain acts shall be prohibited or restricted for the purpose of sabo for flood-control viewpoint.

Rivers in Japan have flooded countless times and have caused enormous amount of damage to the basin areas. The cause of such flooding was known to be closely related to destruction of the mountains upstream. Sediment is generated from devasted mountain areas every time it rains, which flows into the river, raising the riverbed to form a raised bed river. At the same time, a large amount of sediment is carried by flood flows, which takes up a major part of the flow section, and the sediment deposition becomes high enough to make the land after a flood appear more like a sediment-related disaster than a flood disaster. No matter how much river improvement works are implemented including the raising of riverbanks, widening of the river, dredging up of accumulated sediment, or other means, river improvement in the downstream section does not yield results unless measures are taken to prevent or control runoff of the sediment generated in a devasted or denuded area upstream.

The purpose of preventing sediment discharge from causing floods and generating disasters in this way or preventing sediment runoff, i.e. sediment-related disasters, is “the purpose of sabo for flood-control viewpoint.”

To this end, a legal frame work was established to designate destroyed areas that generate sediment, and areas with tremendous river destruction, etc. as designated sediment control areas where harmful acts should be regulated or controlled and proactive sabo works should be implemented.

Accordingly, protection of basins from flood and sediment-related disasters requires interrelated functioning of three laws: the Forest Law (1896) for the conservation of mountains, the Sabo Law for the prevention of sediment discharges and the River Law (1896) for the protection of downstream areas from flood disasters. These three laws are often collectively referred to as “Three Laws for Flood Control” **(Figure 1)**.

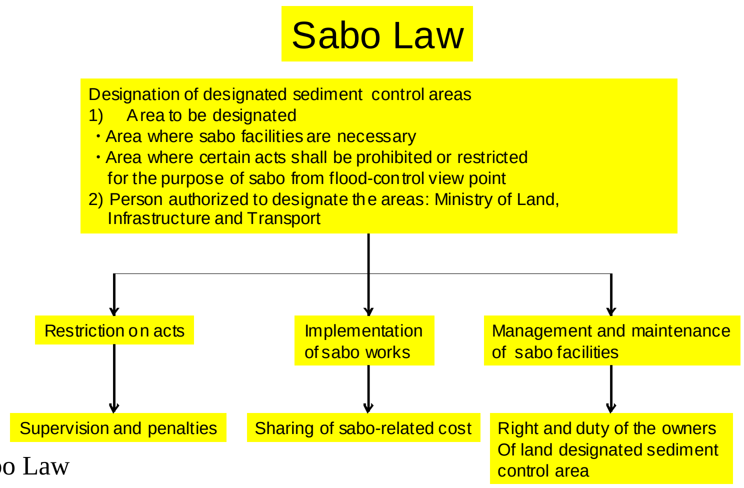


Fig.1. Concept of Sabo Law

Landslide Prevention Low

In 1957, a landslide disaster struck the northern part of Kyushu. Saga and Nagasaki Prefectures, which suffered especially severe damage, enacted the Ordinance Concerning Financing of the Moving of Houses in Landslide Hazard Areas and made strong requests to the national government for the enactment of a landslide law as the fundamental measures including the promotion of landslide prevention works, restrictions on landslide-inducing activities and house relocation.

Landslide prevention measures had already been taken for sabo, forest conservation and farmland conservation projects based on the Sabo Law, Forest Law, etc. However, measures for landslides in urban fringes, which were difficult to implement with sabo from a flood-control viewpoint as mentioned in the Sabo Law, could not be taken with sabo projects, and the Landslide Prevention Law for the purpose of comprehensive landslide measures was therefore issued on March 31, 1958 as Law No. 30 and went into effect on April 1 **(Figure 2)**.

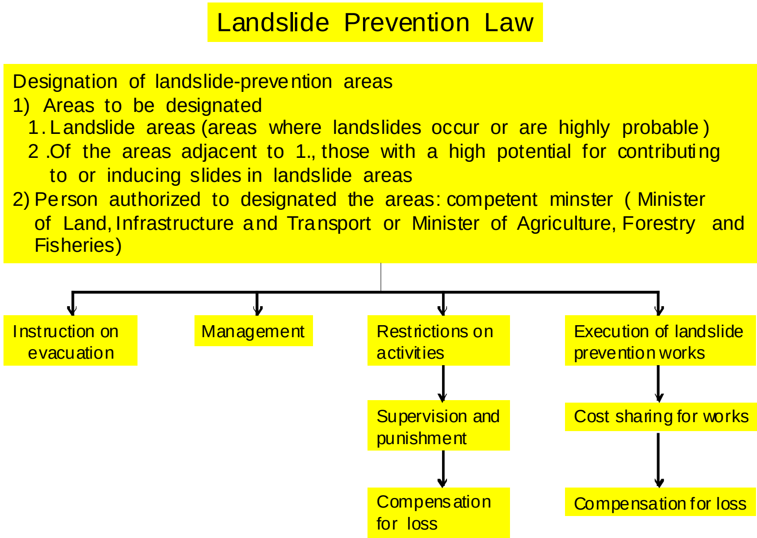


Fig. 2. Concept of Landslide Prevention Law

Law for Prevention of Disasters due to collapse of Steep Slopes

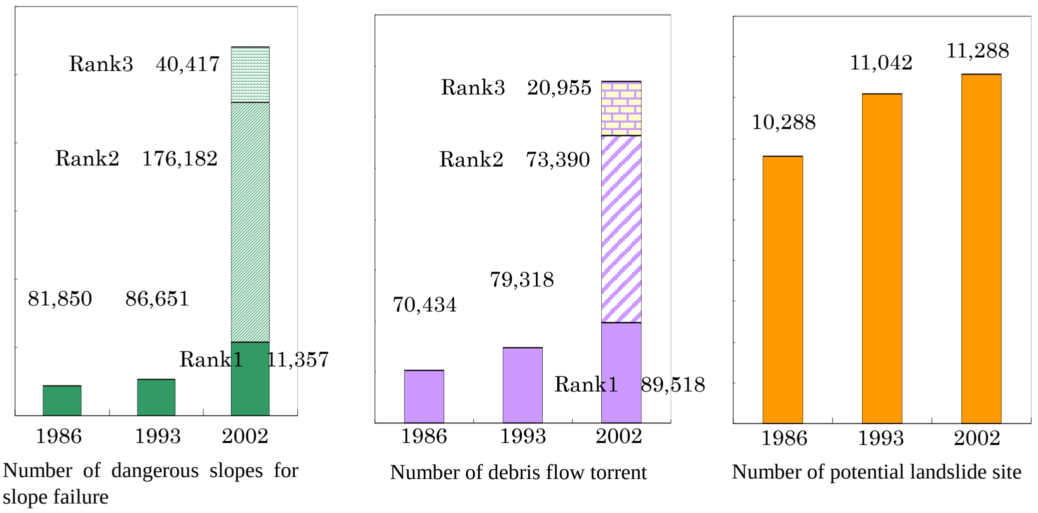
In July 1967, a tropical low pressure system, which was Typhoon No. 7, weakened, stimulating the stationary seasonal rain front. It moved from west to east over the two days from the 8th to the 9th from the northwestern part of Kyushu through the Chugoku to Kinki Regions and caused heavy rainfalls in Nagasaki, Saga, Hiroshima and Hyogo Prefectures. Subsequently, the stagnation of the rain front resulted in downpours in Niigata and Toyama Prefectures between August 10 and September 13 and Typhoon No. 34 also caused heavy rainfall in Wakayama Prefecture at the end of October. The rainfalls both comprised locally severe rainstorms with a maximum daily precipitation of over 300mm and brought about serious damage.

In this year, sediment-related disasters caused 455 deaths including 92 in Rokko, Hyogo Prefecture and 88 in Kure City, Hiroshima Prefecture **(Photo 4 and 5)**.

Photo 4. Slope failure in Kobe city (July 1967) [2)]

Photo 5. Slope failure in Kure city (July 1967) [3)]

In response to successive slope failure disasters, the Ministry of Construction conducted an emergency investigation in the same year on slopes subject to failure, which showed that there were 7,400 such slopes nationwide (the number has now greatly increased as with debris flow torrents, along with improvements in investigation techniques and accuracy in addition to the concentration of population, as shown in **Figure 3**).



Rank 1: an area with 5 or more houses to protect
Rank 2: an area with 1-4 houses to protect
Rank 3: an area currently with no houses to protect that may become a hazard area in the future
Fig. 3. Number of dangerous spots for sediment-related disasters [4]

In this way, the slope failure in Kobe and Kure Cities, etc. in 1967 led to the enactment of the Law on Prevention of Disasters due to Collapse of Steep Slopes, commonly known as the Steep Slope Law, on July 1, 1969 **(Figure 4)**.

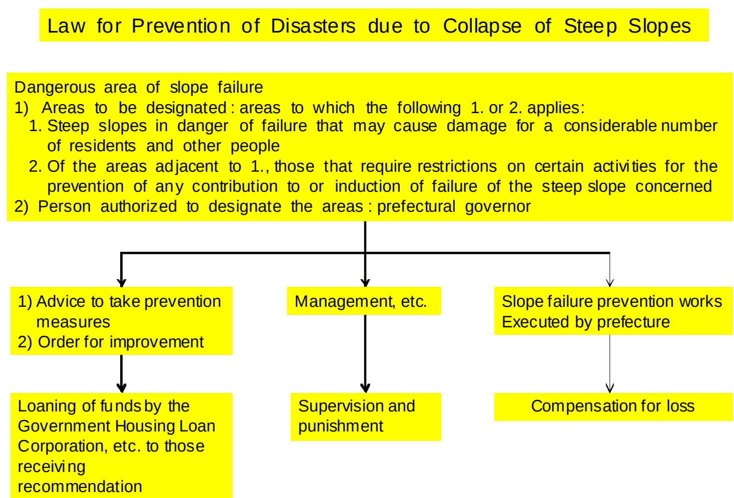


Fig.4. Concept of Law of Disasters due to Collapse of Steep Slopes

Regarding the purpose of the law, it states that the law "is aimed at taking measures required for the prevention of slope failure to protect people from disasters caused by slope failures, thereby contributing to the stabilization of people's lives and the conservation of national land."

Among the vast number of laws, there are not many which clearly mention as their purpose the protection of people's lives.

In Article 2, a steep slope is defined as a slope with an inclination of at least 30 degrees. Article 9 states that the party under obligation to conserve and maintain a slope is primarily the owner, manager or occupant of the land and secondly the party that may suffer damage from slope failure should take measures to remove or mitigate damage from failure.

Regarding slope failure prevention works, Article 11 provides that, when it is recognized as difficult or inappropriate for the owner, manager or occupant of the steep slope or the party who may suffer damage to implement the works, the governor of the prefecture concerned should execute the works.

In either case, the area concerned must be designated as a dangerous area for slope failure under Article 3 of the law. In reality, however, it is difficult to gain the understanding of the potentially affected residents by area designation alone and the designation is usually on the premise of slope failure prevention works.

Sediment-Related Disaster Prevention Law

On June 29, 1999, an intensive rainstorm hit a region stretching from Hiroshima to Kure City in Hiroshima Prefecture as the seasonal rain front became active. Regarding the precipitation that fell, the total amount of continuous rainfall between 0:00 to 24:00 on the day was 255mm and the hourly amount of rainfall between 14:00 and 15:00 was 63mm according to records taken at the Uokiri Dam observatory. The geology of Hiroshima Prefecture is characterized by widely distributed granite, which becomes brittle if weathered, and the prefecture has the most debris flow torrents and dangerous slopes for slope failure in all of Japan. For this reason, the prefecture has suffered numerous sediment-related disasters since early times. The 1999 incident claimed the lives of 24 people in sediment-related disasters.

Issues identified by the Hiroshima disaster and other recent disasters include:
・Efforts must be made to provide valid information and warning and evacuation systems on a routine basis.
・Facilities to protect vulnerable people from disasters and houses located without regard of security for sediment-related disasters and new residential areas tend to suffer damage, and vulnerable people from disasters account for a large proportion of the total of damage sufferers.
・Considering the low level of the rate of improvement for dangerous spots for sediment-related disasters (20 percent) and the vast number of dangerous spots that exist, improvement requires substantial budgetary amounts and a long period of time. In addition, the number of improved areas exceeds that of new dangerous spots every time the list of dangerous spots is revised.
Issues concerning the current system include:

・Whether a given place of residence is subject to sediment-related disasters or not is unclear.
・Location restriction policies by restricting housing land development or construction in areas in danger of sediment-related disasters are not sufficient.

With these challenges and issues taken into consideration, the Committee for Study of Systems under the Sediment-Related Disaster Prevention Law established by the Ministry of Land, Infrastructure and Transport presented the suggestions as follows:
・Designation of sediment-related disaster warning areas (areas subject to sediment-related disasters) and warning and evacuation systems should be improved.
・Location restriction policies, etc. should be implemented in special sediment-related disaster hazard areas (of the sediment-related disaster warning areas, those prone to cause significant damage to the lives and physical health of residents, etc. in. the event of sediment-related disaster).
・Basic investigations concerning sediment-related disasters should be conducted.
・Guidelines for the prevention of sediment-related disasters should be drawn up.

After the Hiroshima disaster, the Law related to Promotion of Measures for Sediment-related Disaster Prevention in a Restricted Area etc. Due to Sediment-related Disaster (Sediment-Related Disaster Prevention Law) was enacted as Law No. 57 on May 8, 2000 with the suggestions of the committee taken into consideration, which is significant in the following respects:
・The law has no provision on works as structural measures for the prevention of sediment-related disasters but is intended to protect residents from sediment-related disasters by non-structural measures including the improvement of warning and evacuation systems, etc.
・While the existing laws concern areas that may cause disasters (sources), this law has its focus on areas that suffer damage in disasters.
・From the viewpoint of prevention of damage, this law goes hand in hand with development permission and building certification systems.
・This law expects synergy between "efforts to provide awareness" by the government and "efforts to become aware" by residents.
In 2005, based on the lessons learned from the 2,537 sediment-related disasters that occurred in the previous year, the act was partially amended to further improve the warning and evacuation systems in sediment-related disaster warning areas. The amendment includes the following two points:
・Information including methods of communication for sediment-related disaster information and evacuation areas shall be provided for residents to keep them fully informed using hazard maps, etc.
・The methods of communication regarding sediment-related disaster information provided to facilities mainly used by the elderly, infants, etc. in sediment-related disaster warning areas shall be stipulated in the municipal plans for disaster prevention **(Figure 5 and 6)**.

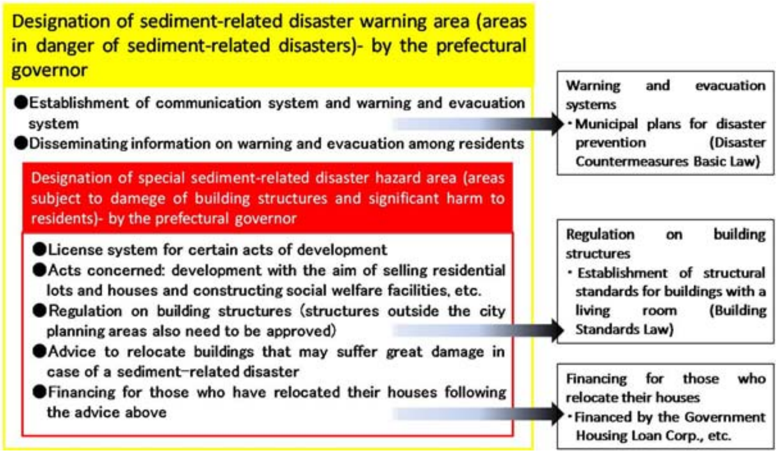
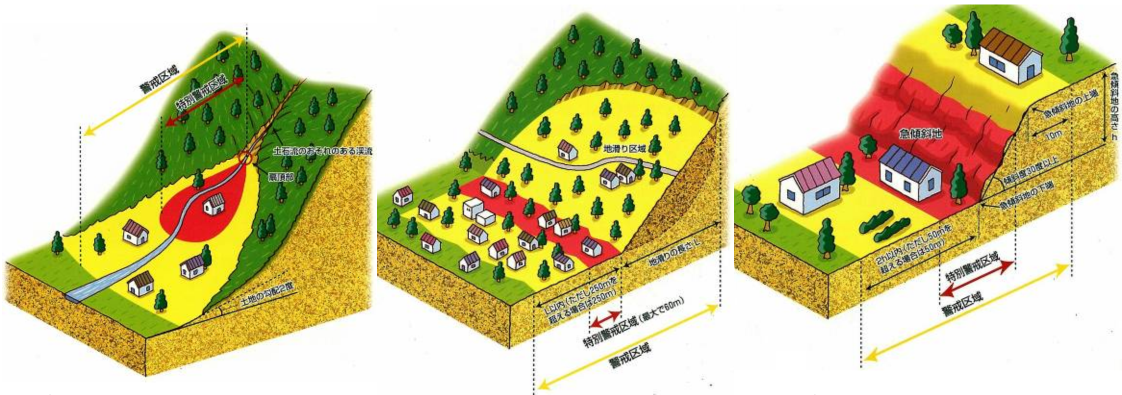


Fig. 5. Concept of Sediment-Related Disaster Prevention Law [5)]

It must be remembered that, unfortunately and regretfully, sabo administration and study have made progress based on the ultimate sacrifice of many lives, which is shown in the transition of sabo administration.



Debris flow　　Landslide　　Slope failure

Fig. 6. Concept of designation of warning areas [forecited 5)]

THE TRANSITION OF SABO WORKS AND TECHNOLOGY

Sabo works implemented by the Shogunate Government

In 1683, the civil engineering technician and merchant Zuiken Kawamura visited the source of the Yodo River and offered his opinion to the Government that the prevention of sediment runoff causing blockage at the mouth of the Yodo River required sabo works upstream.

In 1689, the Government appointed the three clans as doshadome bugyo (magistrate in charge of sabo) and constables under four town magistrates in Kyoto and Osaka as doshadome kata (official in charge of sabo). In addition to these regulations and forestation works, the techniques of direct sabo to control sediment generation itself discharged from bare or devastated mountains by simple hillside works proved effective coupled with the establishment of implementation systems and organizations (Indirect sabo means sediment control that uses structures such as dams to indirectly control the sediment generated and discharged. Needless to say, both direct sabo and indirect sabo are important.). As a result, the concept of forest improvement became even more enhanced.

The technical capabilities of those days are believed to have been far from sufficient in dealing with natural disasters such as earthquakes and volcanic eruptions and there was nothing that could be done except to regard such phenomena as acts of God and wait until the situation became manageable. That is why stringent regulations were imposed to counter ever greater destruction due to human-induced causes such as unrestrained logging that would lead to disasters.

Sunadome of the Fukuyama Domain

In Fukayasu County, especially in Kannabe Town, of the Bingo District in the eastern part of Hiroshima Prefecture, about 50 Sunadome sabo dams still exist that were constructed during the Fukuyama Domain period. This area is in the Ashida River Basin that stretches across Hiroshima and Okayama Prefectures. The river is one of the largest in the Chugoku Region with its source located in Daiwa Town of Kamo County, Hiroshima Prefecture (at an altitude of 570m), and a basin area of 860 km^2 and a main channel length of 86km.

The topography of the basin can be characterized by plateaus 200-500m above sea level in the upstream area and alluvial plains including the Kannabe and Fukuyama Plains in the downstream area. The climate can be classified as mild Inland Sea climate with an annual mean temperature of 12-15 degrees C. The precipitation of the area is only about 2/3 of the national average with an annual rainfall of 1,600mm in the upstream region and 1,200mm in the downstream area.

The geology is mainly composed of granite generated at the time of igneous intrusion, which was physically weathered into decomposed granite soil and has become prone to erosion by flowing water.

In the Fukuyama Domain, the concept idea of Sunadome was apparently developed in around 1697 and there is mention of Sunadome in a village document dating from 1734 in existence; a few of such dams still remain in their original shape today.

Katsunari Mizuno, the first feudal lord of the Fukuyama Domain, was a cousin of Ieyasu Tokugawa and the Abe Family, which took the lordship later,and was a powerful hereditary vassal of the Tokugawa Shogunate. This naturally gave the successive feudal lords of the Fukuyama Domain important posts for administering state affairs including members of the Council of Elders. Agricultural fields that generated money to cover the expenses for serving such posts were an important source of revenue and Sunadome that would protect the fields from disasters were the most essential facilities of the Fukuyama Domain. Especially during the lordship periods of Masayasu Abe in the 1830s and that of Masahiro Abe, who became the premier member of the Council of Elders, construction of Sunadome reached its peak **(Photo 6)**. These Sunadome still remain as robust structures that provide a sense of security in the area.

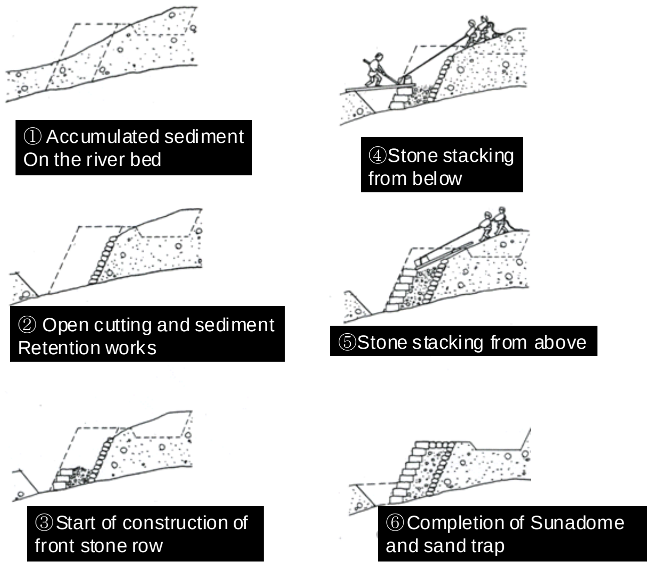


Fig. 7. Presumed method of Sunadome construction [7]

Photo 6. Portrait of Masahiro Abe [6]

The Sunadome sabo dams are also reasonable in terms of their structural design and it is a source of pride that these structures built in the Edo period are by no means inferior to the masonry dams in various regions of Japan believed to have been built under guidance of de Rijke, a Dutch engineer employed by the government in the Meiji period.

1) Fukamizu Sunadome (dam height: 4.1m, dam length: 25.4m)
On hillsides, which provide a source of sediment, generation of sediment is directly prevented by hillside works and discharge due to unstable sediment in the mountain stream and erosion of banks is prevented by the dam, which also stops the sediment from the upstream area to indirectly control the sediment discharge downstream. This superb integration of direct and indirect sabo shows that the aim of sabo projects was already achieved here.

This Sunadome includes three levels and the bottom was constructed in 1854, an addition of 1.8m was built as the middle level in 1864 and the wing was raised in 1883, which comprises the form the dam is now. With the two large distinctive mirror stones mounted at the center of the middle level, which communicate the desire to keep disasters away, the beautiful masonry dam/Sunadome is reminiscent of an ancient castle. The planar shape presents a gentle arch and the front slope inclination is about 6 arcmin **(Photo 7)**.

2) Dodo River Sunadome No. 6 (dam height: 13.3m, dam length: 55.8m)
This is the largest of all the existing Sunadome. The Dodo River includes six large dams over its main flow starting with the first Sunadome downstream up to this sixth one, and ten smaller Sunadome in the upstream region. The large number of Sunadome as compared with the basin area of 2.7 km^2 indicates that the area was seriously devastated in past

disasters.

The original Sunadome was a large dam mentioned in a record from this period entitled “Toto Yoteki”: “Shimogoryo Village: In July 1835, laborers were signed up for the construction of the big Sunadome along Toto.” The works to enlarge the dam were started in 1835. The original Sunadome was apparently built in 1773, which was used as the foundation for building the lower layer in 1835 and the mid layer added for bank raising in 1882. On top of it is the uncoursed masonry in the upper layer, which had its stones removed once and restacked at the time of implementation of the sabo environment improvement project in 1976 for lowering the channel works in the sedimental area. In short, the dam is composed of four layers built in the three periods of Edo, Meiji and Showa.

The sedimental area has been developed as a park and provides a place not only for local festivals and events but also for recreation and relaxation **(Photo 8)**.

Photo 7. Fukamizu Sunadome [forecited 7)]

Photo 8. Dodo River Sunadome No. 6 [forecited 7)]

Major Methods of Sabo Construction in the Edo Period

Initially, hillside works comprised mostly plant works, but torrent control works gradually became common and dams built with stones as in the Sunadome in the Dodo River of the Fukuyama Domain came to be constructed. This is likely to have provided a good grounding for smooth technology transfer from the Western countries that occurs later in the Meiji period.

Dutch and Japanese sabo engineers

Engineers Van Doorn and Lindo were invited from the Netherlands in February 1872 and Escher, Thissen, de Rijke and others came to Japan as government-employed engineers the following year.

The Dutch engineers returned back home in succession one after another by around 1880 (Mulder went back to the Netherlands in May 1890), except for de Rijke, who stayed in Japan for 29 years until 1901 and made significant contributions and left great achievements in the improvement of the entire civil engineering technology not to mention sabo and social capital enhancements in Japan.

The assignment of Van Doorn was aimed at making improvement plans for major rivers and providing instructions on the sabo works. The opinion brief he submitted after visiting the Fudo River (Kizu River System: Yamashiro Town, Soraku County, Kyoto) in 1873 provided the basis for the Yodo River Water Source Sabo Law described earlier.

In 1874, de Rijke also conducted an investigation in cooperation with Escher on the conditions of destruction in the upstream region of the Yodo River, for studying the cause of riverbed aggradation at the mouth of the Yodo River. After this investigation, the Dutch engineers proposed prohibition of unrestrained logging, implementation of hillside works and construction of sabo dams in the upstream region for stabilizing the downstream river sections. This was the beginning of the flood control works under direct control of the Ministry of Home Affairs, which was conducted in the Kizu River Basin under the guidance of de Rijke and company in 1874. At this time, de Rijke submitted an opinion brief that suggested the following:

1. The side of accumulated sediment should be provided with rows of straw bundles dug into it for the prevention of sediment runoff.
2. Dams of wood, stone, earth, etc. should be built in valleys in low mountains.
3. Measures should be taken to protect the banks of the raised bed river running from the foot of the mountain into the Kizu River.

In 1875, De Rijke supervised the implementation of sabo works in the Fudo River, which Van Doorn had visited, covering 16 methods including masonry dam **(Photo 9)**. In Hontani, in particular, he constructed a huge masonry dam 64m in length for securing water for agriculture, the right bank of which was partly damaged by the Minami Yamashiro Flood Disaster in August 1953. Later a new sabo dam was built downstream and unfortunately the original dam has been lost **(Photo 10)**.

Also in 1875, Kyoto engineer Yoshikata Ichikawa constructed the Aitani Dam, a large masonry dam with a reservoir, in Aitani of the same basin, which is still in existence more than 130 years later **(Photo 11)**. Ichikawa is famous for devising sodding work, a unique Japanese technique for hillside works, as compared with the straw bundle row works designed and invented by de Rijke, and he is also known as the author of “Suiri Shimpo,” a comprehensive guide to flood control and sabo technology in Japan **(Figure 8 and 9)**.

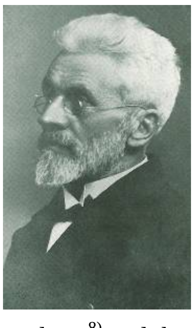



Photo 9. De Rijke in his later days [8] and the De Rijke Dam (in the Fudo River)

Photo 10. Hontani Dam immediately after the Minami Yamashiro Flood Disaster in 1953 [9)]

Photo 11. Hontani Dam built by Yoshikata Ichikawa [forecited 9)]

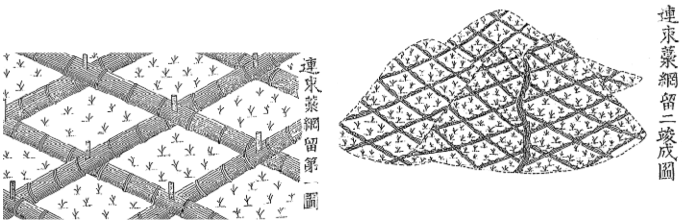


Fig. 8. Straw bundle row works [forecited 7)]

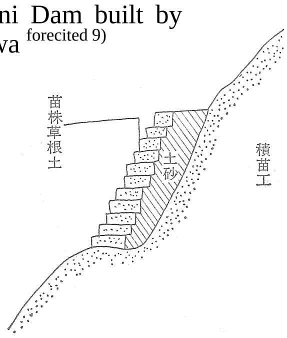


Fig. 9. Sodding work [forecited 10)]

Another noteworthy Japanese engineer of remembrance in addition to Ichikawa is Gisaburo Tanabe. Before dying an early death at the age of 32, Tanabe designed and built the Dutch Dam and the Yoroi Dam in the Tanakami Mountain System located in the upper reaches of the Seta River of the Yodo River System, which even today maintain their beautiful appearance and secure the safety of the downstream reaches **(Photo 12 and 13)**.

Photo 12. Dutch Dam [forecited 7)]
(Courtesy of the Otsu Forestry Office of Shiga Prefecture)

Photo 13. Yoroi Dam [forecited 7)]
(Courtesy of the Otsu Forestry Office of Shiga Prefecture)

De Rijke brought with him to Japan his wife Johanna, daughter Anna, son Jan and his wife's sister Elsje but lost his sister-in-law in 1879 to cholera. In 1881, his wife also died in Japan, when she was only 32 years old.

De Rijke left the following remarks behind as he left Japan:

1) For river projects in Japan, characteristics of the individual river must be thoroughly understood in advance. It is also important to have a good understanding of the necessity of forest conservation and sabo as the basis of flood control.

2) Regarding forest conservation projects in mountains in the upstream areas, sabo projects in the midstream and upstream regions and river projects in the downstream areas,

administration and investigations must be conducted under an integrated system encompassing from the upper reaches to the river mouth.
3) Based on the preceding two points, it is necessary to be prepared to continuously measure various data on the individual rivers for an accurate understanding of their characteristics.

These words of advice remain valid today. His achievements include his presentation on the importance of sabo to the government and his efforts to secure budgets for sabo in addition to technological expertise.

Subsequently in 1903, Amerigo Hoffman of Austria came to Japan and provided guidance on the design of sabo works in Seto City, Aichi Prefecture. This led to more exchanges with Austria for Japan’s sabo technology, including the study visits to Austria by Kitaro Moroto, then an assistant professor at Tokyo Imperial University, and Masao Akagi of the Ministry of Home Affairs.

SABO PROJECTS UNDER THE DIRECT MANAGEMENT OF THE NATIONAL GOVERNMENT

The beginning of direct management of sabo works comprised half of the expenses for the Yodo River repair works in the Seta and Kizu Rivers (both in the Yodo River System) allocated to sabo cost as the supplement cost for prefectural sabo works in 1878.

The first sabo works under the direct management based on the Sabo Law were conducted in the Fuji River, which started in 1911. The ongoing sabo works in the Yodo River were continued as works covered fully by the national treasury not under the Sabo Law.

The Sabo Law provides that the national government may directly conduct the execution of construction of sabo works when:
・Sabo facilities are necessary for preservation of other prefecture's interests
・The interests of sabo facilities are not limited to within one prefecture
・The construction is considerably difficult, or
・Construction cost is considerably high.

Following the enactment of the law, sabo projects under the direct management of the government based on the law were commenced in the Kiso and Yodo Rivers, in which sabo projects had been implemented before the enactment. While sabo works were conducted sequentially in devastated basins as sabo areas under direct management based on the provisions of the Sabo Law, the sabo projects under direct management for general safety of the basins by intensive promotion of construction were handed over to prefectural governors for implementation as subsidized sabo projects.

Sabo projects under the direct management of the government are intended to protect human life and assets from disasters by conserving basins and preventing riverbed aggradation in downstream rivers due to sediment generated and discharged from the basins.

Volcano sabo projects under the direct management of the government are aimed at protecting human life and assets from disasters caused by abnormal sediment discharges including volcanic mudflows, pyroclastic flows and lava flows resulting from volcanic eruptions, etc. by conserving basins in devastated volcanic areas and riverbed aggradation in downstream rivers due to sediment discharges.

SUBSIDIZED SABO PROJECTS

Only a few sabo projects were conducted by prefectures prior to the enactment of the Sabo Law: Kyoto started in 1873, Yamanashi in 1881, Okayama, Gifu and Shiga in 1883 and Osaka in 1888. All of them mainly involved the utilization of hillside works.

The enactment of the Sabo Law clearly defined subsidized sabo projects and projects started in Nagano, Gifu, Shiga and Okayama Prefectures in 1898 as subsidized sabo projects under the law. Subsidized sabo projects were also implemented in Fukushima, Tochigi, Mie, Fukui, Osaka and Hyogo Prefectures in the following year (1899) and more projects took place 1900 in a total of 19 prefectures including Osaka and Kyoto.

In 1932, to help save impoverished farm villages from the serious recession caused by the Great Depression, the government implemented the Public Works Program for Relief to Farmers as an unemployment measure.
Meanwhile, the number of subsidized sabo project-implemented prefectures increased from 26 in 1931 to 40 in 1934.

In 1972, a subsidized sabo project was started in Okinawa Prefecture, which was the last prefecture to commence sabo works in Japan.

Disaster that spurred the start of debris flow control measures

On September 25, 1966, a settlement in Ashiwada Village (present Fujikawaguchiko Town) on the north coast of Lake Saiko, one of the Fuji Five Lakes, was hit by a debris flow. 31 people died in the Saiko District (population of 513) and 63 people died in the Nemba District (population of 235). The disaster was triggered instantaneously at around 1:00 a.m. and lasted some 30 minutes **(Photo 14)**.

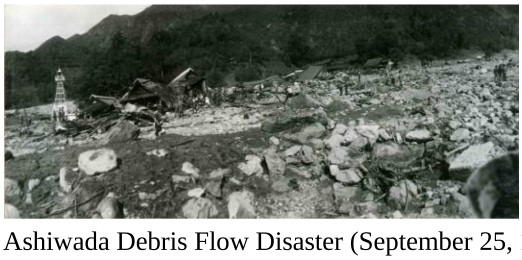


Photo 14. Ashiwada Debris Flow Disaster (September 25, 1966) [11)]

a. Nemba District struck by the disaster b. Saiko District struck by the disaster

The Ministry of Construction issued a Sabo Division Director's Notice entitled "Submission of Data on Hazardous Mountain Streams" to the prefectures on October 14 of the same year to conduct an investigation. As a result, it was announced that there were 15,645 "mountain streams that may be hit by a debris flow, adjacent to settlements subject to direct damage in the event of such flows," thereby potentially affecting some 430,000 homes. This disaster prompted the implementation of debris flow control measures intended for the protection and preservation of settlements.

Disaster that spurred the start of non-structural measures

From 7:00 p.m. to 10:00 p.m. on July 23, 1982, an hourly rainfall amount exceeding 100mm continued, and the Nagasaki Flood Disaster centered around the City of Nagasaki City left 299 people dead or missing, 805 people seriously or slightly injured, 584 houses totally collapsed and 954 houses partially collapsed. Victims of sediment-related disaster accounted for 74 percent of all victims.

Nagasaki, a city characterized by many slopes, contains numerous dangerous spots for sediment-related disasters. The Nagasaki Disaster indicated the need for comprehensive sediment-related disaster measures in areas with a convergence of zones subject to debris flows, landslide and slope failure as well as the significance of so-called non-structural measures, i.e. education of residents on accurate information about sediment-related disasters, early evacuation and securing of safe evacuation centers and evacuation routes. This disaster encouraged the implementation of non-structural measures including the Sediment Disaster Prevention Month, which started the following year **(Photo 15)**.

Photo 15. Nagasaki Flood Disaster (1982) [12]

a. Susukizuka Town immediately after the disaster

b. Narutaki Town immediately after the disaster

LANDSLIDE CONTROL PROJECTS

Landslide control projects can be classified by operating body into those under the direct management of the national government and those subsidized and executed by prefectures.

Landslide control projects under direct management

Article 10 of the act provides that the competent minister may execute landslide prevention works at his/her own discretion if any of the following conditions apply and such works are recognized as particularly important for the conservation of land:

・In the case the scale of landslide prevention works is particularly large
・In the case the landslide prevention works require high technology
・In the case the landslide prevention works need to be executed using high mechanical force
・In the case the landslide prevention works extend over the boundary of prefectures

Landslide control measures are executed by the Forestry Agency when the land concerned is forestland and by the Ministry of Agriculture, Forestry and Fisheries when the land concerned is farmland. Accordingly, the Ministry of Land, Infrastructure and Transport executes the works in other cases. The competent minister is the Minister of Land, Infrastructure and Transport and Minister of Agriculture, Forestry and Fisheries.

On April 20, 1962, the first landslide control project under the direct management of the national government was commenced in Jinnosukedani in the Tedori River System (Shiramine, Hakusan City, Ishikawa Prefecture). Since then, projects have been implemented in places such as Kamenose in the Yamato River System (Kashiwara City, Osaka Prefecture) and Toyomaki in the Mogami River System (Yamagata Prefecture)

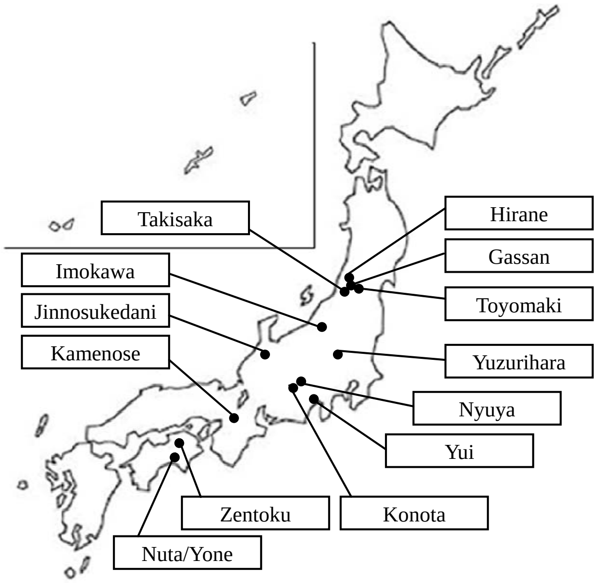


Fig. 10. Sites of landslide control projects under the direct management of the government [13)]

Subsidized landslide control projects

Old records show that landslide prevention works were executed in Nagano Prefecture in 1886 independently by the prefecture. Since the enactment of the Sabo Law in 1897, landslide prevention works have been conducted as sabo projects in areas specified as designated sediment control areas from a flood-control viewpoint. Subsequently, the frequency and extent of damage due to landslides tended to increase in many parts of Japan; to cope with this landslide control project expense was budgeted in the sabo project expenses in 1937.

In 1952, landslide control projects were established as subsidized projects under Article 16 of the Local Finance Law. As a result, the scope of works covered was extended from those implemented from a flood-control viewpoint to include those that might have major impact on society or the economy irrespective of flood control.

The enactment of the Landslide Prevention Law in 1958 enabled the establishment of subsidized landslide control projects based on law.

SLOPE FAILURE PREVENTION

Beginning of slope failure prevention projects

On the slopes of mountains after a front accompanying a typhoon or rainstorm has passed, denuded section of land resembling a scar can be found. When the population was smaller than now, such oral information concerning disasters passed down from generation to generation was reflected in the lives of people. People who never lived in areas subject to direct impact of collapsed soil were aware that such soil from destroyed areas fell into rivers, and caused the raising of riverbeds downstream.

While shrines, temples and long-standing houses were located in safe areas, the progress of civilization and the development of industry led to a population explosion in Japan. Japan's national land accounts for only 0.3 percent of the global total of national land area, and of this limited area as much as 3/4 is occupied by mountains and hills. The amount of land was not adequate enough to accommodate the population increase and some people were forced to live in mountainous regions which pose danger. The influence of this manifested itself as earthfall disasters. In particular, the concentration of population into urban areas in the high-growth period encouraged the development of new residential areas in piedmonts near urban areas and accelerated the repetition of slope failure.

Measures for slope failure, which directly cause damage to human life and occur suddenly and instantaneously, were strongly called for by various sectors. In response to this background, it was decided in 1967 that 1/2 of the expense for slope failure prevention works executed by prefectures would be subsidized by the national government under the budget support system.

SLOPE FAILURE PREVENTION PROJECTS

Slope failure prevention projects are conducted by prefectures.

Slope failure prevention projects

Along with the enactment of the Steep Slope Law, slope failure prevention projects under the government subsidy system began.

Photo 16. Retaining Wall (Source: MLIT)

Photo 17. Crib Works (Source: MLIT)

CONCLUDING REMARKS

It is too late if disaster prevention measures are taken after the disaster. Therefore, the basic principle is to prevent disasters before they occur, and to mitigate damage to the lowest possible level if the disaster scale is large.

For that purpose, establishment of laws and rules and implementation of Sabo projects are indispensable. It is also important to accumulate disaster prevention measures continuously. As is known from our disaster prevention history, Japan has revised laws, systems, and technologies from time to time to reflect the changes in the disaster type and damage level, as well as the changes in the government system, socio-economic situations, and people's lifestyles.

These years, the number and scale of sediment-related disasters are increasing under the influence of major earthquakes, climate change due to global warming, and local heavy rains (Figure 11 Number of heavy rains and sediment-related disasters) (Photo 18 Mid-Niigata Prefecture Earthquake, Photo 19 Iwate-Miyagi Nairiku Earthquake, Photo 20 heavy rain at Hofu City). As shown in Photo 18 to 20, large-scale disasters occurred in Japan. In the case of disasters that spread damage onto vast areas, the earliest possible response is very important. To enable central and prefectural governments to directly provide technical assistance to the affected municipalities, our sediment-related disaster prevention law was revised. Without disaster prevention, the national development may be difficult. Therefore, what is desirable is to build a disaster-resistant country in a concerted effort of the central and local governments and local people. To make it successful, we consider it is important to look back on the disaster prevention history of our own country.

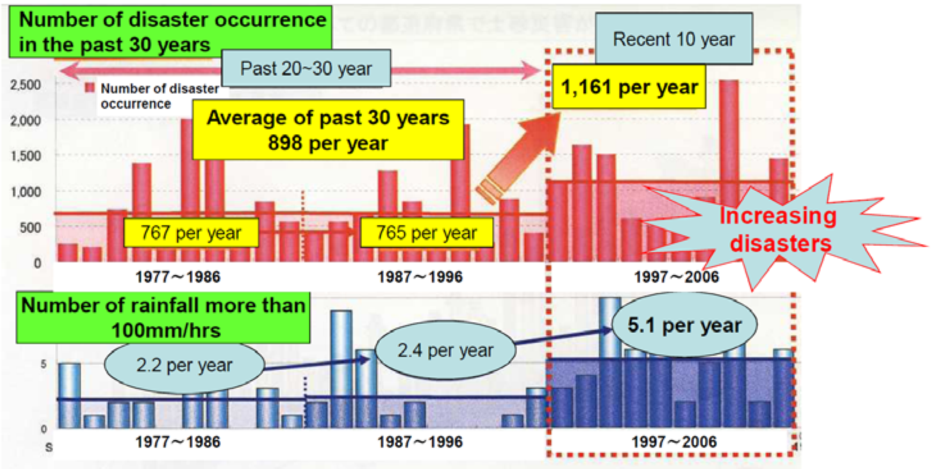


Fig. 11. Number of heavy rains and sediment-related disasters forecited 4)

Photo 18. Mid-Niigata Prefecture Earthquake
(Quoted from the website of MLIT)

Photo 19. Iwate-Miyagi Nairiku Earthquake
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Photo 20. Heavy rain at Hofu City
(Courtesy of Yamaguchi Prefecture)

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