HISTORICAL WATER PROJECTS IN KYUSHU DISTRICT, JAPAN, AND A CURRENT PROJECT IN AFGHANISTAN

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ABSTRACT

Approximately 400 years ago, in the Sengoku era, Kiyomasa Kato developed three rivers - the Shira-kawa River, the Midori-kawa River and the Kikuchi-gawa River - in Kumamoto Prefecture in the Kyushu district of Japan, using traditional river engineering methods. The residents of this watershed called Kiomasa the god of water control. Two hundred thirty years later, during the Edo Period, the Yamada-zeki Weir at Asakura City, Fukuoka Prefecture, was constructed to regulate the flow of the Chikugo-gawa River, the largest river in Kyushu, and to direct water to the region's paddy fields. Remarkably, this highly effective weir was constructed without large-scale equipment. Moreover, there has been little impact on the ecosystem. Now, wisdom from the Edo era is being applied in an effort to save the world. As a prominent example, in 2010, a Peshawar Association NGO, which for 30 years has been providing support for the reconstruction of Afghanistan, completed construction of a weir and a waterway using the Yamada-zeki Weir as a model.

Keywords: Kiyomasa KATO, Tetsu NAKAMURA, diagonal weir, willow trees and gabions, Green infrastructure

1. INTRODUCTION

This study investigates the old wisdom in Kumamoto and Fukuoka Prefecture in the Kyushu district of Japan, and how the technique is effective for the reconstruction of Afghanistan. The information provided can enhance the knowledge on the old wisdom about water utilization method by escaping flood effects. The knowledge and successful application to the Afghanistan case should be spread in the world.

1.1 Kiyomasa KATO

Government by the military (the feudal society) spanned the 12th to the 19th century in Japan. The period from 1467 to 1573 is known as the Sengoku era, which translates to the "era of civil wars" in English. During this period of continuous war, feudal lords divided the land of Japan and battled one another to expand their personal territories. The Sengoku era ended with the emergence of Hideyoshi TOYOTOMI, whose strong leadership unified the country. Kiyomasa KATO was one of the subordinates of Hideyoshi TOYOTOMI. In 1588, Hideyoshi TOYOTOMI appointed Kiyomasa KATO to rule half of the Province of Higo (the present Kumamoto Prefecture) in Kyushu. This appointment was extremely fortunate for the people of Higo Province, as Kiyomasa KATO excelled not only in fighting but also in civil engineering.

Documents of Tosa Ooki, a general servant of Kiyomasa, indicate significant knowledge of river surveys. More specifically, they provide five rules of flood control (Tanigawa, 2006):

1) Investigate rivers carefully, not on the surface of the water, but in areas with undercurrents and severe water contact.
2) When building embankments, do not build them near rivers.
3) Toss and revetment construction must not be done. Don't attempt to run the water down the river quickly without preparation of the water.
4) When deciding the river width, carefully examine the flow of the tide and the wind direction
5) When contracting, listen to the opinions of the river manager and the elderly, and carefully consider the opinions of young people before recruiting.

Photo.1 Damaged triple water wheel at Asakura (30th Jul. 2017)

In 1789, one triple water wheel and two double water wheels were built, and the same water wheels that were used 220 years ago are now

Note: The Japanese suffixes -kawa and -gawa mean 'river', -zeki and -seki mean 'weir', -ko is 'lake', -tei is 'bank', -domo is 'weir' and/or 'open levee', -ide is 'channel' and -minato is 'port'.

operating, irrigating 20,400 tons, and irrigation area 35ha per day (Asakura city office site, 2011). The triple-wheeled water wheel is still in operation, and was damaged by heavy rain in northern Kyushu in 2017 (Photo 1), but has been restoreds now.

1.2 Hyakkou KOGA

Hyakko KOGA (1718-1798) was born in what is today Asakura City. He devoted his entire life to the development of the Yamada-zeki Weir and other river control facilities. In 1790, when Hyakko KOGA was 73 years old, he oversaw a major renovation of the Yamada-zeki Weir and the Hori-kawa River irrigation canal (using 620,000-640,000 men). As a result, 490 ha of paddy fields were irrigated, including 120 ha of new fields (Nakamura, 2017).

1.3 Tetu NAKAMURA

Dr. Tetsu NAKAMURA (1946-2019) was born in Fukuoka Prefecture. He provided medical support in Peshawar, Pakistan, and established the Peace Medical Society (PMS), an NGO aid group. After a devastating famine following a severe drought in 2000 in Afghanistan, which is adjacent to Peshawar, PMS dug wells and restored a number of qanats. Officially, other NGOs dug wells, but, in actuality, these NGOs served only in a management capacity; the digging was left to low-level local contractors. PMS was the exception, digging 1,600 deep wells and reviving 38 qanats. While the wells and revived qanats secured the supply of drinking water, ensuring sufficient water for agricultural use was difficult due to the low water level of the Kunar River. At this point, Dr. Nakamura, a medical doctor with no formal training in civil engineering, decided to shed his lab coat and work to develop an irrigation canal. In his words, "One irrigation canal will do more good than 100 doctors." His engineering knowledge was almost entirely self-taught. Under his direction, construction of the Marwarid Canal began in 2003. It took seven years to complete the 25 km irrigation canal, but it has now turned a good portion of the desert green. Unfortunately, Dr. Nakamura was felled by a deadly bullet in December 2019; however, the project remains ongoing. For security reasons, there are few English translations of this tragedy, but his death has brought a change in security protection (Nakamura, 2013)

2. METHODS

2.1 Kiyomasa KATO at the Shira-kawa, Midori-kawa rivers and Kikuchi-gawa River in Kumamoto, Japan

2.1.1 *River improvement of the Shira-kawa River*

When Kiyomasa KATO arrived in Kumamoto, the central area of Kumamoto city was a large area flooded by the Shira-kawa, Tsuboi-gawa and Iserigawa rivers running in disorder. Kiyomasa proceeded to change the channel of the Tsuboi-gawa River to fill the moat of Kumamoto Castle and divided the Shirakawa and Tsuboi-gawa rivers to mitigate the flooding (Fig. 1) (Kumamoto River National Highway Office, 1995).

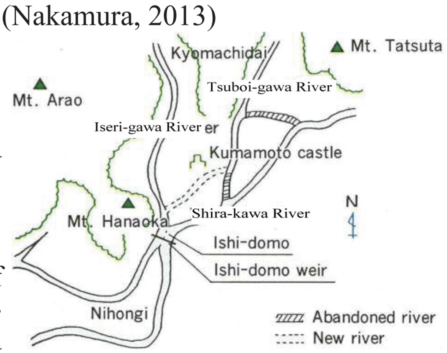

Fig.1 River improvement of the Shira-kawa River by Kiyomasa(Kumamoto River National Highway Office,1995)

2.1.2 *River improvement of the Midor-kawa River*

Next, Kiyomasa, with a view to protecting the Kumamoto Castle town and the paddy field surrounding it from the flooding of the rivers, constructed an embankment (Kiyomasa-tei) along the Kase River (a tributary of the Midori-kawa River), starting from Lake Ezu-ko (Fig. 2). Thinking that the Kiyomasa-tei would not be enough to endure the flooding of the Kase-gawa River, Kiyomasa switched the Mifune-gawa River to the mainstream of the Midori-kawa River. Furthermore, in order to fix the mainstream of the Midori-kawa River, which had frequently changed its course due to flooding, Kiyomasa KATO had the river bed dug deeper and an embankment (Daimyodomo) constructed. It should be emphasized that Kiyomasa purposefully avoided the construction of an embankment on the left bank of the Kase-gawa River to reduce the damage of flooding in downstream regions by turning the triangle area surrounded by the Kiyomasa-tei and the Daimyo-domo into a "retarding basin" (Kumamoto River National Highway Office, 1995).

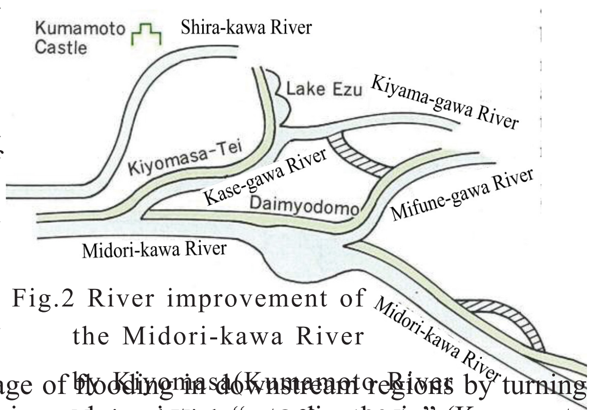

Fig.2 River improvement of the Midori-kawa River by Kiyomasa 1(Kumamoto River National Highway Office,1995)

a) Kutsuwa-domo (Kasumi bank : Open levee)

Kiyomasa mostly used Kutsuwa-domo to reduce floods. In this method, the flood velocity is weakened by widening the distance between both banks at the point where two rivers meet or at the point where the water violently strikes the bank. However, the mere widening of the distance between embankments would cause inconvenience to navigation in the river because it would change the river course in times of low water due to flooding. Consequently, a Kasumi-tei bank (open levee) was constructed to stabilize the river course during the low-water time. This made it possible for the inhabitants to use the land between the Kasumi-tei bank and the main bank as farmland. The construction of the Kasumi-tei bank had another advantage: Because of its presence, when a flood occurred, the flood waters brought large quantities of rich soil into the farmland. This added to the primary benefit of reducing the damage done by floods to human life and farm crops, as the Kutsuwa-domo caused the flood waters to flow slowly into the farmland from the end of the Kasumi-tei bank (Fig. 3) (Kumamoto River National Highway Office, 1995).

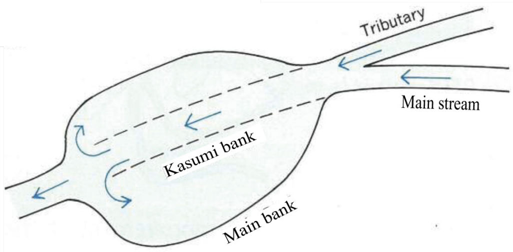

Fig.3 Kutuwa-domo(Kumamoto River National Highway Office,1995)

b) Unose-zeki weir

Kiyomasa constructed an irrigation weir on the spot where the Midori-kawa River entered from the mountain area into the plain. However, each time a weir was built, it was soon destroyed by a flood. In response, Kiyomasa developed a weir that crossed the river diagonally instead of at a right angle to the flow of the river. With this modification, there was no further flood-induced destruction of the weir. Because the shape of the weir resembled a U (a cormorant), this weir was called the Unose-zeki Weir (Fig. 4). Kiyomasa constructed many facilities to make effective use of the water, including the Unose-zeki Weir, and, as a result, helped increase the production of rice by 70% (Kumamoto River National Highway Office, 1995).

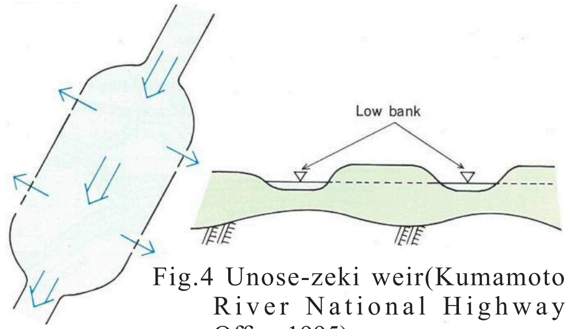

Fig.4 Unose-zeki weir(Kumamoto River National Highway Office,1995)

c) Hanaguri-ide Channel

In constructing the headrace from Babakusu Weir in the middle reach of the Shirakawa River, it was necessary to tunnel a small hill. As mentioned in Section 2.1.1, the Shirakawa River has a great deal of "yona," volcanic ash sediment, at its bottom, which would make maintenance of the tunnel (that is, the dredging of the sedimentation) difficult if the tunnel were built with a normal structure. Accordingly, as shown in the Fig. 5, the tunnel was constructed with a short diameter and bridges built at appropriate intervals, so that the water surface resembled a staircase. In this way, the flowing water was made to be constantly stirred in order to prevent the accumulation of yona. This facility, called the Hanaguri-ide channel, is still in use today (Kumamoto River National Highway Office, 1995).

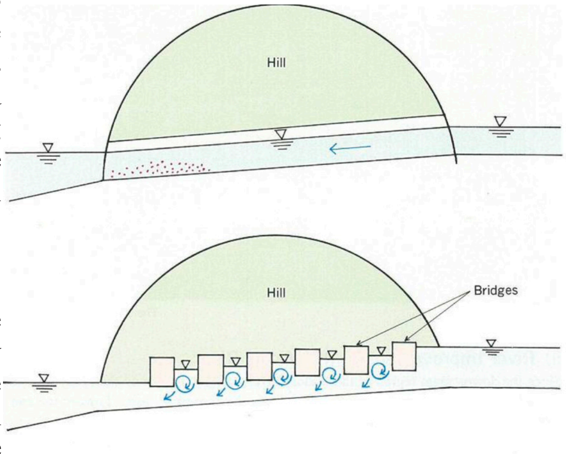

Fig.5 Hanaguri-ide Channel(Kumamoto River National Highway Office,1995)

2.1.3 *River improvement of the Kikuchi-gawa River*

Kiyomasa also renovated the Kikuchi-gawa River, providing the foundation for the current Kikuchi-gawa River. He implemented river channel replacement, conducted reclamation projects, and provided for the maintenance of boat navigation routes centering on Takase-minato Port. In addition, a river stone groynes system was developed in a downstream section of the river. He also used Kutsuwa-domo here (Kikuchigawa River Office,1991). The stone river groynes were built at a higher position during the Kiyomasa era and are thought to have been a measure against high water levels. In 1994, five large-scale (5-12 m) stone river groynes were built, which, along with eight more that were built in 1997, are responsible for strengthening the banks and providing environmental benefits. (Photo 2).


Photo.2 Stone river groynes at Kikuchi-gawa River:The darkest one was constructed by Kiyomasa KATO ; The right most groyne was constructed at 1997. (https://www.jsce.or.jp/committee/lsd/prize/2002/works/2002b2_3.jpg)

2.2 Hyakko Koga at Chikugo-gawa River, Fukuoka, Japan

In Asakura, Fukuoka, Japan, the development of irrigation canals began in the 17th century. Yamada- zeki Weir, Eri-zeki Weir, Oishi-zeki Weir, and Fukurono-zeki Weir were all constructed at the end of the 18th century. By this same time, Asakura had become a granary, and the

Asakura weirs were initiated not by the Shogunate or a clan, but by the farmers. Hyakko KOGA (1718-1798) provided technical guidance and direction for the project, which took 30 years to complete (Asakura City Office, 2011).

Photo3 Yamada-zeki Weir ; The intake is on the right ; the overthere is drain for sediment ; center to left is stone -paved diagonal weir ; left to overthere is main stream (Photo by Akira Ikuta with drone)

2.2.1 *Yamada-zeki Weir on the Chikugogawa River*

Yamada-zeki Weir is located in Yamada, Asakura-city, and is an "inclined floor stone-paved weir." Here, the width of the Chikugo-gawa River is obliquely blocked by a large area of stone pavement. The "Stone-paved weir" is a valuable heritage that is unparalleled nationwide. It has the following features (Nakamura, 2013):

1) Problems involving water pressure and water volume associated with the rapid flow of the Chikugo-gawa River have presented a number of difficult challenges. These problems have been largely solved by diagonally damming with stones, facilitating the flow of the water to the intake.
2) The cobblestones are widened using megaliths, and the weir has a gentle slope facing downstream, making it difficult for water pressure to be applied and resulting in a natural flow (Photo 3).
3) There is a boat and fishway, as well as a gravel spout.

It is said that more than 200 diagonal weirs have been built since the Meiji era (1868-1920), but the only diagonal weir that has kept its original form in Japan is the Yamada-zeki Weir. At the time of construction, there were no concrete or civil engineering machines; even cows and horses were extremely rare. Although there was iron, it was used only for agricultural tools, and reinforced concrete had not yet been developed, which made a right-angle weir very difficult to construct. It appears that such weirs were washed away almost immediately after construction, which meant that these weirs were constructed and maintained solely by manpower. Yamada-zeki Weir is a 320 m oblique weir with boulders occupying over 25,000 m^2. Three waterways regulate the flow and also serve as a boat and fishway (Nakamura, 2017).

2.3 Tetsu Nakamura and PMS at Kunar River, Afghanistan

The Kunar River has a basin area more than three times that of the model Chikugo-gawa River, and has a flow rate of 150-250 m^3/s in severe winters and more than 3000 m^3/s in summer. Due to recent climate change, flooding occurs frequently in summer, and fields and houses are often washed away through the irrigation canals. On the other hand, the water level declines markedly in winter, which severely affects the harvest of wheat, a staple crop. It is no longer possible to take water with conventional water intake methods. The residents recently attempted to construct a simple jetty to facilitate the taking of water; however, in subsequent summers, scouring occurred at the tip of the jetty and at the sandbar, which further reduced the water level and made it difficult to take water in the winter (Fig. 6). In addition, water that had invaded during the summer floods was allowed to overflow from the waterway to the river, but large floods would still damage nearby fields and houses.

To address the problem, PMS proposed a repair of the intake weir, installation of an intake gate, repair of the main canal, and installation of a sedimentation basin using the PMS method. The first phase of construction of the Marwarid Canal was completed as a PMS-only project in 2010 (Fig. 7), with the aim of irrigating in the Gamberi Desert area. Although the project was successful in irrigating a part of the desert, due to the effects of climate change, the winter water level of the Kunar River dropped and it became impossible to achieve widespread irrigation.

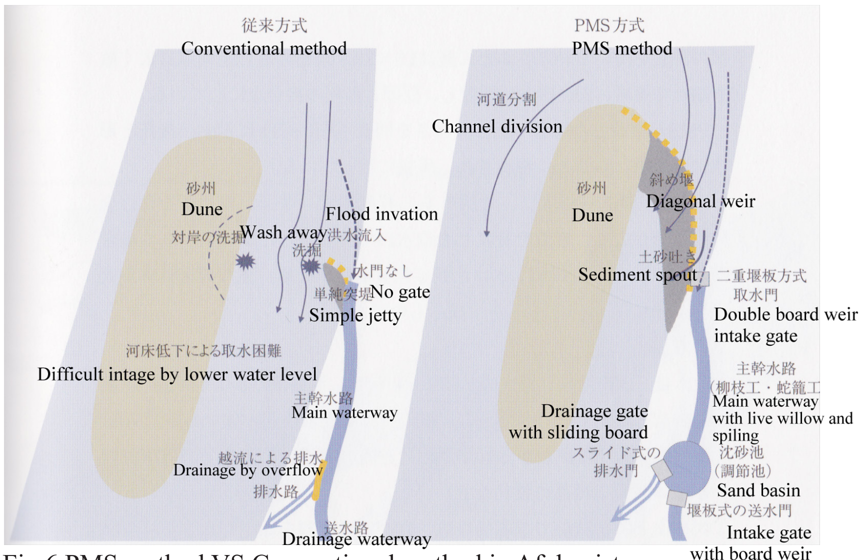

Fig.6 PMS method VS Conventional method in Afghanistan (original :Nakamura, 2017)

2.3.1 *Rehabilitation works related to intake weirs*

Rehabilitation works related to the intake weirs included raising the entire river channel with diagonal weirs, dumping sediment in front of the intake gate and protecting the dam by dividing the river channel.

1) *Rehabilitation work related to intake weirs*

Rehabilitation of the intake weir consists of raising the entire river channel with diagonal weirs, dumping sediment in front of the intake gate, protecting the dam by dividing the river channel, and protecting the opposite bank.

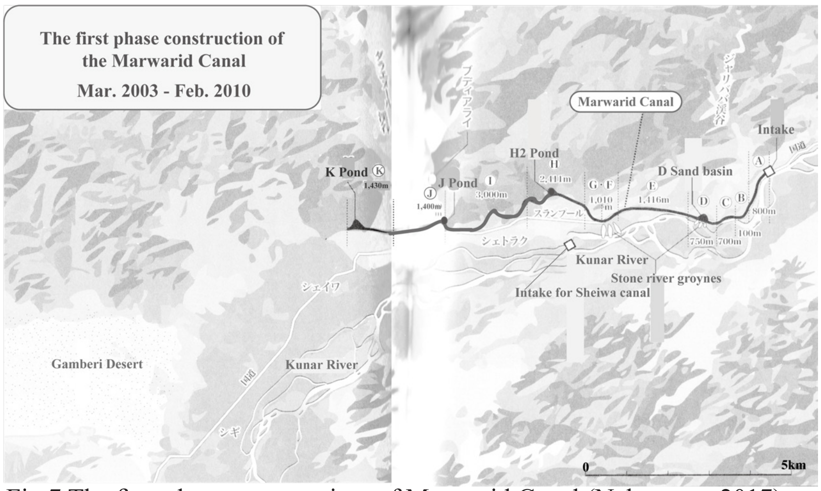

Fig.7 The first phase construction of Marwarid Canal (Nakamura, 2017)

a) Lifting the river channel water using a diagonal weir

The diagonal weir used here is modeled on the Yamada-zeki Weir in Asakura City, Fukuoka Prefecture. By making the overflow width of the weir as wide as possible, the overflow water depth to be passed is suppressed, the load per unit area of the embankment is reduced, and the water level fluctuation is minimized. In addition, the riverbed is prevented from lowering by flooding the entire river channel. The plane of the weir is drawn in a semi-elliptical shape toward the upstream side, and the overflowing water is collected at the center of the river channel to prevent influence on the opposite bank. For large scale flood, to limit the volume of the water exceed the capacity of intake, river channels are divided nearby the weir and ntire sand reef is built into part of the weir.

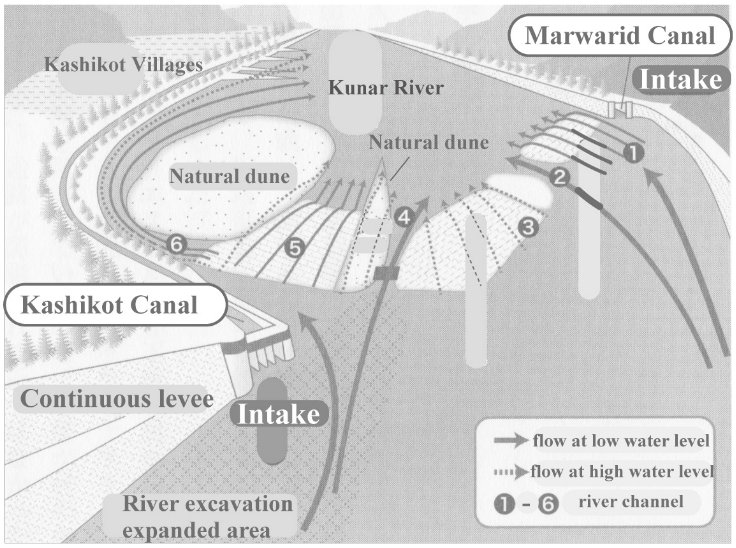

Fig.8 Marwarid-Kashkot Continuous Weir ; Font is upper stream side ; First Phase of Marwarid Canal is completed at 2009 and Kashkot Canal complted at 2013 (original:Nakamura, 2013)

As an example, a Marwarid-Kashkot continuous weir is shown in Fig. 8. The embankment is made of boulders (0.5-2 m) rather than square stones. However, such a structure is weak and vulnerable to scouring, so mattress-type gabions are used (Photo 4). The use of mattress gabions is an important traditional technique that is said to have originated in ancient China, where stones surrounded by bamboo constituted the structure. In 1908, galvanized iron wire replaced the bamboo, and continues to be used in present-day Japan (Japan Jakago Association, 2009). Mattress gabions are also commonly used in Japan to ensure ecological diversity. In the PMS method, large stones are packed on the outside and crushed stone and gravel are packed on the inside without the use of split stones (Fig. 9), stabilizing the housing, increasing the weight, and reducing suction on the back (Fig. 10). In addition to scouring the diagonal weirs and preventing the


Photo4 Mattress gabions at river bank (Nakamura, 2017)

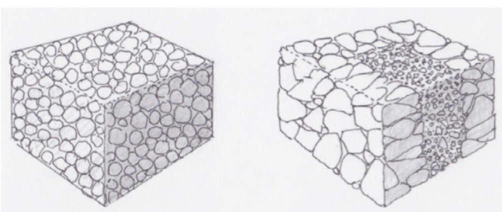
Fig.9 Mattress gabions ; Japanese standard(Left); PMS type is packed large stone outside and cushed or gravel is inside of meshes (Nakamura, 2017)

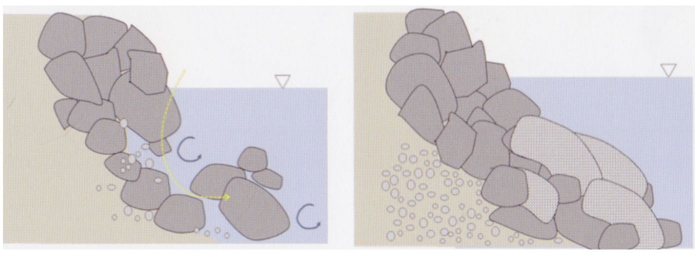
Fig.10 Combination of giant stones with riprap and gabions; Rolling stones may be generated due to the lowering of the riverbed at the tip of the riprap and may cause erosion and the collapse of the embankment (left); The gabions are not washed away because of gabion's plasticity and permeability. If placed at the tip, gabions will be stuck between the boulders and will not easily cause rolling out of boulders (right) (Nakamura, 2017)

boulders from rolling out of the weir, the gabions are used for the inner walls of irrigation canals, revetments and consolidation, and to prevent the collapse of cliffs along traffic routes. Above all, being able to produce the necessary materials locally is an important feature (Nakamura, 2017). This project also uses vegetation, that is, green infrastructure. Willow trees and willow fences are employed. Willow trees are especially effective when combined with mattress gabions. Mulberry, olive, eucalyptus, etc., are also used. Recently, for biodiversity, eucalyptus is gradually being replaced by locally grown viera and sissow(Nakamura, 2013).

b) Intake gate and sediment spout

The intake gate is indispensable, as the Kunar River carries a large amount of sediment. PMS has installed a double weir gate made of reinforced concrete (Photo 5). In this method, gates with a width of 1.5 m are lined up side by side to withstand the summer floods; in response to the low water levels in winter, standardized weir plates made from wood (Photo 6) are moved up and down. The raising and lowering of the plates are performed manually by Chalha, a local host (Photo 7). In this way, the river water is allowed to overflow

Photo5 Double plate weir gate at Kashkot weir opposite side of Marwarid weir; winter season (Nakamura, 2017)

Photo6 Standardized weir plate ; 19kg, easy to move(Nakamura, 2017)

Photo7 Chalha (Nakamura, 2017)

with clean water, the flow rate is controlled and sediment inflow is suppressed. Furthermore, by using a double weir plate, the water pressure on the back is used to counter the water pressure on the front (Fig. 11). This development was a breakthrough in Afghanistan. In front of the intake gate, a mud spit is installed (Nakamura, 2017), dividing the river channel upstream of the intake to avoid severe tractive forces acting on the intake during a flood (Fig. 6).

2) Rehabilitation of main waterway

A steep main trunk channel is provided after the intake gate, and is composed of a soil cement lining, gabions, and willow trees on the bank. The gradient is set at 1/660 to ensure a flow velocity of 1.2 m/s. Manning's coefficient has been calculated to be 0.012-0.013 (Nakamura, 2017). This waterway flushes the sediment to the next sand basin, an idea inspired by Kiyomasa Kato's Hanaguri-ide channel mentioned above.

3) Setting up a sand basin

Sediment is temporarily deposited in a sand basin, then drains through the drainage gate to the river with lower water. The water supply gate as well as the intake gate uses a weir board to supply water and provide defense during floods (Fig. 11). The Triple Arch Gate is an original model based on the 10th Gate in Yatsushiro, Kumamoto Prefecture, Japan. The prototype of the pond also refers to the dikes of Miike, Oomuta-city and Kiyotaki in Koga City, Fukuoka Prefecture, Japan (Nakamura, 2007; Nakamura, 2017).

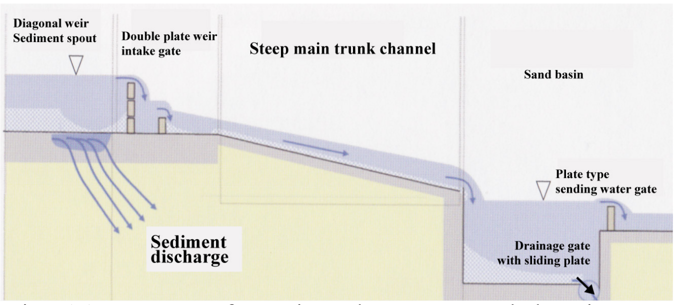

Fig.11 From after intake to sand basin (original:Nakamura, 2017)

4) Rehabilitation of main waterways(F and G sections)

The main channel after the sand basin is optimally set to have a gradient of 0.0006-0.001. The principal problem here has been the embankment construction, which is easily broken. In response, a number of measures are taken (Fig. 12):

1. Provide sufficient consolidation by preloading with slow rate.
2. Make the waterway lining thicker.
3. Make the embankment wide enough so that the water table does not reach the back slope of the bank.
4. Thickly cover the outer wall with gravel or rock, and densely plant mulberry, willow, olive, etc.
5. In case of soft ground, use the sand mat method.
6. Cut the steps with reference to the terraced paddy fields near Tsujun Bridge (Photo 8), and divide the earth pressure into

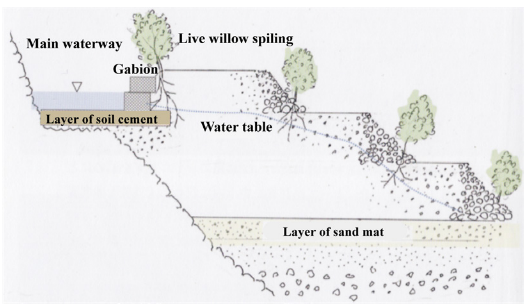

Fig.12 Cross section of main waterway (original:Nakamura,2017)

Photo8 Tujun Bridge with terraced paddy field (Nakamura, 2013)

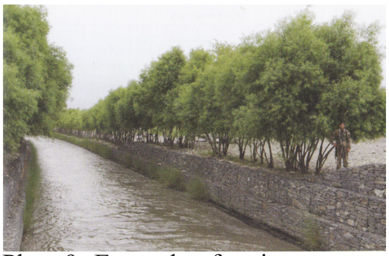

Photo9 Example of main watereay with willow trees and gabions (Nakamura, 2017)

Photo10 Backing overflowed flash flood and reduces velocity by trees (Nakamura, 2017)

each step.

7. Cover the running water surface with soil cement utilizing local soil.

These were the most difficult sectors in the developement of the canal(Photo9) (Nakamura,2017).

5) Installation of reservoir(H,J,K,Q sections)

Along the irrigation canal, reservoirs have been created that also serve as buffer ponds for local debris flows in summer. There are 10 locations with a bank length of 50 m or more (e.g., Fig. 13). Trees are planted around the pond to slow the velocity of rapid flash floods (Photo 10) (Nakamura, 2017).

6) Installation of Siphon

Siphons were installed (Fig. 14) below the waterways in the F, G, H, J and K sections. Siphons have been used in Japan since ancient times. This is a debris flow measure working along with the buffer ponds (Nakamura, 2017).

7) Recovery of drainage channel

In arid regions, headraces are frequently developed, but drainage is often treated as having no value. However, drainage is important, as the summer rains in this region there are very heavy rainfall and floods often strike fields and dwellings along the irrigation canals. PMS has developed a drainage network with a total length of 50-60 km at the end of the Marwarid Canal. The structure is nearly the same as the irrigation canal, but completely separate from it (Nakamura, 2017)

8) Installation of a continuous levee and stone river groynes (D and F section)

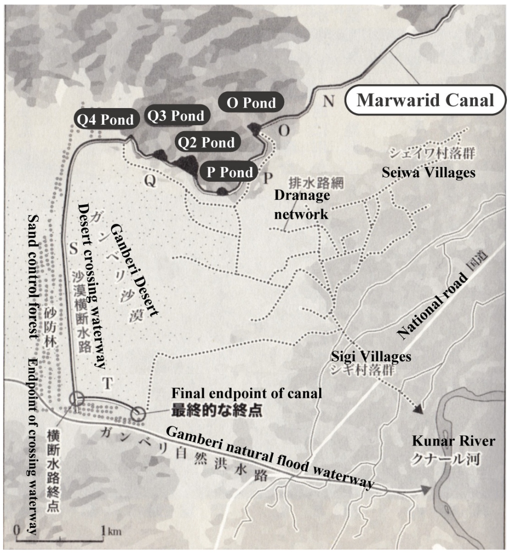

Fig.13 6 ponds made near Gamberi Desert after 2010 (original:Nakamura, 2013)

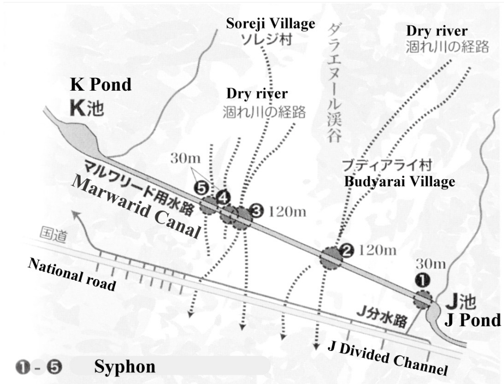

Fig.14 Siphons are installed between J and K pond (original:Nakamura, 2013)

The revetment of the Kunar River adjacent to section D and F was washed away due to other development and flooding, and was at risk of collapse. There are 26 stone river groynes with a scale of 15-30m (Photo11), which are scaled up stone river groynes (length 5-20m) in Midorikawa River mentioned above, and 30 embedded stone river groynes of about 5-10m length. This building was easy because a lot of boulders are produced locally, but heavy equipment such as dump trucks and loaders was required (Nakamura,2017).

Photo11 Stone river groynes at oposite side of Mirane Weir (Nakamura, 2017)

9) Installation of Pumped water wheel

Diesel pumps were already installed but they had a low pumping volume and the fuel was rather costly, so two pumping water wheels (Photo 12) modeled on the Asakura triple water wheel were installed to serve villages in the irrigation area (Nakamura, 2017).

10) *Installation of a sand control forest*

The endpoint of the Marwarid Canal is the Gamberi desert (Fig. 13) and has been often damaged by sandstorms. When the irrigation canal was constructed, a sand protection forest 5 km long and 300 m wide was planted (Photo 13). The species used were gaz, eucalyptus, vieira and sissow. Through 2016, a total of 350,000 trees had been planted.

3. RESULT

The first phase construction of Marwarid Canal was completed in 2010, extending from the intake point of section A to section K. During construction, frequent natural and man-made disasters occurred; however, in each case, project elements were completed with improvements and through constructive negotiations.

Photo12 Water wheel at Kunadi Village (Nakamura, 2017)

photo13 Sand control forest: right (Nakamura, 2017)

As a result, approximately 3,000 ha of irrigated land was successfully created. Project cost totaled $16,496,529, all of which was funded by donations from Japan. The task of irrigating the Gamberi Desert has been undertaken in the second phase of construction; as of the end of March 2017, water was being supplied to irrigate 16,500 ha of land and serve the needs of approximately 650,000 people, the result of both the PMS project and a joint project with JICA (Japan International Cooperation Agency) (Nakamura, 2017). Japanese workers have participated in the construction, but most of the workers are local farmers. For the most part, materials and tools are readily available locally. Because the project's heavy equipment uses local general-purpose products, the work can be sustained locally even if PMS were to withdraw. Indeed, 71% of those who have worked with PMS have stated that they can teach others the know-how that they have acquired (Nagata, 2016).

4. CONCLUSIONS

Applying Japanese traditional and technical methods to modern day Afghanistan has facilitated the construction of sustainable irrigation canals. That said, reinforced concrete was used in the construction and heavy machinery was used to expedite the handling of the many boulders that were needed to be put in place during the winter season, when it does not rain. Thus, these traditional methods would not have been possible in the Edo period.

Although Dr. Nakamura died as a victim of the conflict in Afghanistan before full completion of the project, it is likely that his will and techniques were programmed from the beginning to be passed on to the Afghan people. It is clear that frequent droughts will continue to occur throughout the country as the snow lines in the mountains continue to rise with the progression of global warming. "Water from bullets" is synonymous with the security that has been described since ancient times, "after enough fooding and wearing, people will be knowing good manners." Despite the chaos that persists in Afghanistan, it is my sincere hope that the development of sustainable PMS-based infrastructure will continue to contribute to the country's general welfare well into the future.

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