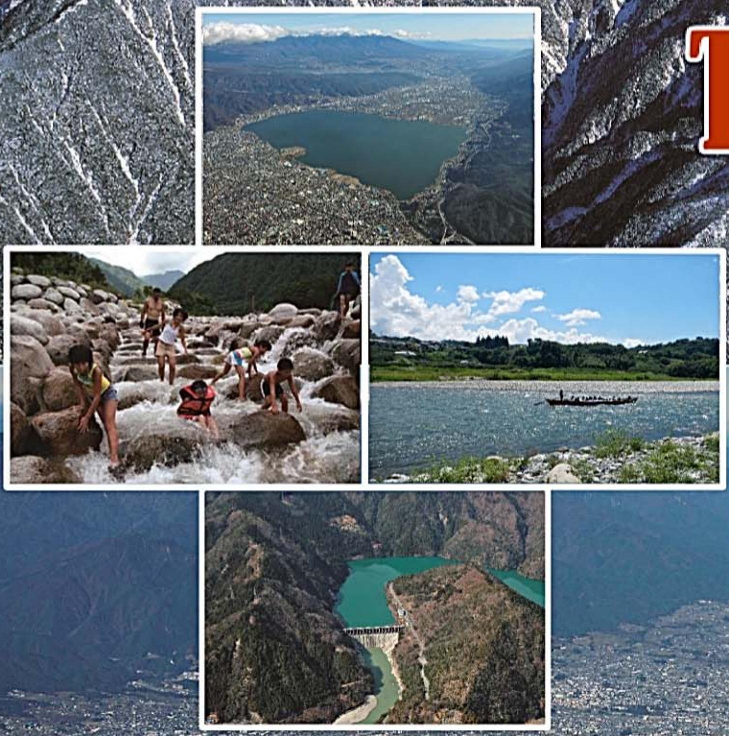
The Upper Tenryu Reach



Tenryu River Upper Reach Office
Chubu Regional Development Bureau
Ministry of Land,Infrastructure,Transport and Tourism,JAPAN

The Upper Tenryu Reach

1.Hydro-geologic features of the upper Tenryu reach from a geo-tectonic viewpoint: how the river was formed (“*kawanari*”)

1-1.Hydro-Geology

The Japanese Archipelago was generated from relative motions of four interacting tectonic plates drifting with different velocities and directions, namely, Pacific Plate, Philippine Plate, Eurasian Plate, and North American Plate, on the east coast of the Eurasian Continent. Its geology was made complex by diverse sea-floor sediment deposits piled up and surcharged at the continental plate boundary of the archipelago as exotic terranes by oceanic plates in a colliding tectonic convergence process through which plates are subducted, as opposed to oceanic crust creation on divergent boundaries. The relative motion of the colliding plates brought trench subductions and the corresponding uplifts in the continental plates. The Japanese islands stand as a break water, so to speak, for the Eurasian sea coast against *tsunamis* induced by dip-slip faulting in sea trench subduction zones of the Pacific Ocean. Volcanic arcs were formed in the Japanese inlands by hot magma plumes from deep spots of subduction zones, as it was not the boundary of inter-continental convergence. Volcanoes caused additional active lifting and

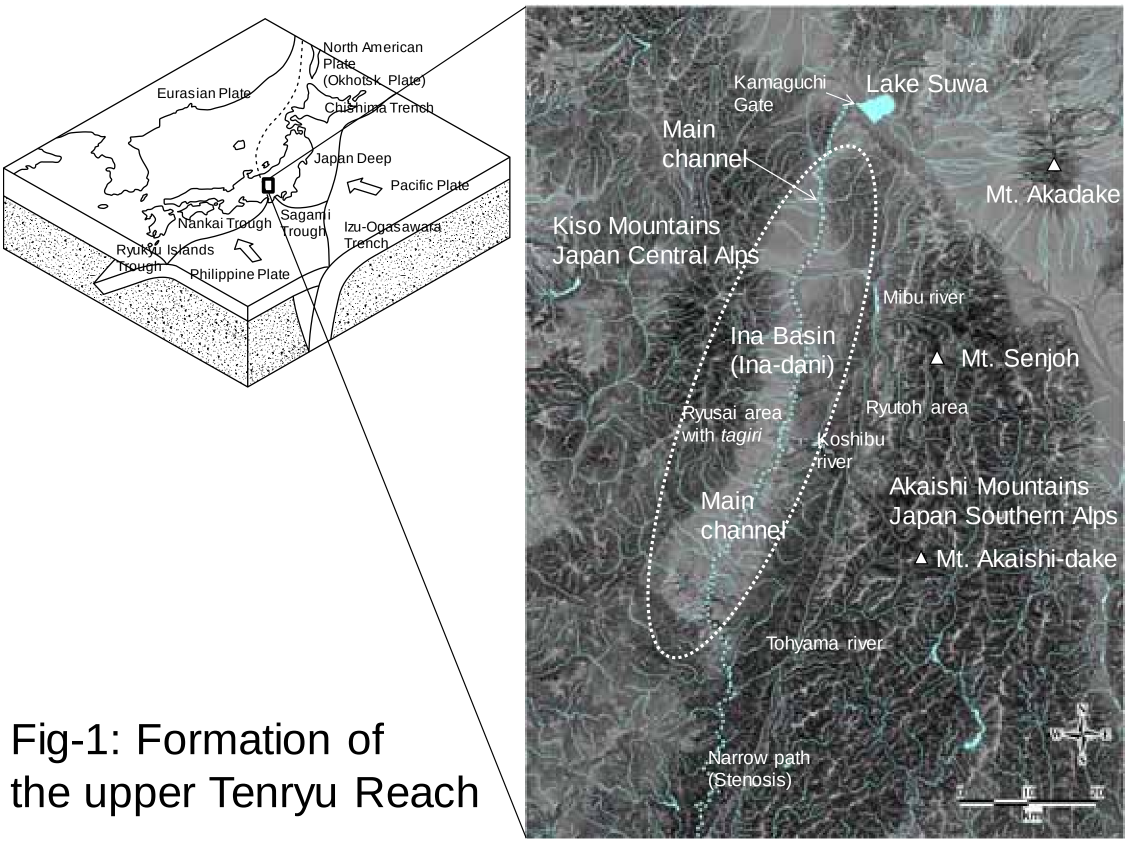


Fig-1: Formation of the upper Tenryu Reach

Fig-2: Geology of the upper Tenryu reach

metamorphic volatilization of the geology. The geo-history of north-eastern and south-western parts of Japan is mostly describable as an interplay of two corresponding sets of tectonic plates. On the other hand, the geo-history of the middle part of the Japanese main island (*Honshu*) demands the comprehension of the in-between interplays of these two sets of oceanic and continental plates.

The Japanese median tectonic line turns out to be a far wider tectonic topography of Fossa Magna in the middle part of Japan that stands between the north-eastern and south-western parts. The tectonic line is simply running parallel to Philippine-Eurasian plate boundary in the south-western part of Japan. The western margin of Fossa Magna is called Itoigawa-Shizuoka tectonic line in particular.

Lake Suwa, a rift lake, was formed at the center of the Japanese main island by transformative relative motions between two sets of plates, four in total. The lake region is the highest part along the tectonic line between rising mountain ranges. The rift lake forming Suwa basin called for an exit of water for lack of sufficient evapotranspiration. Runoff from the lake was made possible by its relative height along the tectonic line. The south western section became its way-out as a result of cumulative tectonic uplift protrusion in its surrounding and a runway blockage on the south eastern section by eruptions of Yatsugatake volcanoes. Water runs off southwardly into Ina basin, also a tectonic basin, which is lower than the lake and slanting gently towards the south.

The same relative motion of plates folded the median tectonic line and brought forth a discontinued section in the rising mountain range. The section, a kind of kink, became a weak line playing a role as a southern water way-out for Ina basin to prevent the impoundment the basin as a whole; and thus the upper Tenryu reach, “Ina-dani,” came into being with a due water outlet into the Pacific Ocean.

The relative motions of the plates and distribution of intra-plate geologic weak lines caused a series of westward shifts of uplift zones in the basin from one era to the other. As a result, the present trunk channel of the upper Tenryu river is situated on the western part of the basin, along Ina-dani fault line between the Akaishi mountain range (the Japanese southern Alps) and the Kiso mountain range (the Japanese central Alps).

Long principal tributaries of the river have as their catchments an older north-south tectonic lineament, seen particularly in the eastern “*Ryutoh*” region. These tributaries run westward to join the main channel of Tenryu river through passes dividing low-rising "*Ina-sanchi*" hills lying at the western edge of the lineaments. Younger western "*Ryusai*" region has not seen sufficient development of north-south tectonic lineaments. Tributary gorges, therefore, run eastward with steep gradients to hit the main channel straightly. The gorges entrench rising mountainous ranges deeply. The western gorges, going down still-rising Ryusai terraces, have dynamic flows and form "*Tagiri*" (namely incised paddy fields, or literally 'charged'). Tagiri is an incised riverine terrace with high cliffs between stream beds and tablelands with a trace of debris fans on it. The western gorges promptly meet the main trunk of strong transport power, which itself has entrenched its own course.

Picture: Tagiri in Ryusai area
(Ohtagiri River, Komagane-Miyada)

The south-bound main channel, as it runs down, sees occasional obstacles of geologic blocks with high erosion-resistibility and narrow pass sections of stricture left mostly untouched by wash-out effects of attacking tributary streams. The main channel is restrained by stenosis sections. It flows out to the southern side of the mountains, which are still in the uplifting process despite its discontinuity due to the kink of the median tectonic line. The middle part of Tenryu river, dissecting the upper and lower reach, is an antecedent valley in a tectonically uprising mountainous range, where erosive main channel gives superiority to entrenchment, while hardly broadening.

1-2. Sediment production

Both Akaishi mountains (the Japanese southern Alps) on the eastern rim and Kiso mountains (the Japanese central Alps) on the western rim of Ina basin are active zones with impressive uprising rates. They have not been subject to embrittlement effects of volcanic alteration, as they are away from the inland volcanic zones. Located inland, sea trench earthquakes, strong as they may be, seem to have had only limited impacts on them. Abrasive effects were seen in high altitudes during past glacial periods. The effects left only minor impacts as their 3000-m heights barely reach the southern tip of the Japanese glacial formation zone since Japanese southern coastlines are found in warmer fluctuating monsoon belts.

The basin stands in The Japanese Pacific climate region, as opposed to that of Japan Sea climate region with much snow. However, the basin has been mostly free of strong precipitation impacts of typhoons and frontal activities seen in monsoon belts, since it is not on coastline but in the inland mountain range. Also, its major orientation runs north-south, causing less orographic precipitation amplification of warm wet air coming from the south. As a result, the basin has not seen much erosion and landslide impacts, even after interglacial periods of Holocene era. It keeps the highest potential of sediment productivity in the Japanese Archipelago, with No.1 sediment wash-out production rate despite the mere 12^{th} status in terms of catchment area. The insufficient erosion and slope failure process left considerable amounts of seabed deposit in shallow layers along the median tectonic line with less metamorphism. The deposit may have derived either from the shallow sea on the eastern edge of the Eurasian Continent or from oceanic plates transported by their drifts, and sometimes accompanied by local accumulation of mineral substances, for instance, through leaching.

1-3. Water utilization

The upstream catchment of the independent basin of Lake Suwa has another irrigation system separated from those of the downstream despite its juxtaposition as a basin. Many farmlands are found on terraces higher than the river channel in Ina basin. Major intake points, where large-scale inlet is possible through dams and/or dikes, are mostly found in eastern principal tributaries of Ryusai. The intake points are limited. In addition, Tohyama river, a major southern tributary, runs off at the lowest end of Ina basin. There remain areas relying on rainwater, groundwater, and local irrigation both for agricultural and potable purposes.

As a consequence, the self-sustaining agricultural productivity and the population accumulation in Ina basin, in themselves, have been limited in spite of thriving traffic of people as a pivotal route from ancient times. Major dams were constructed in the modern era at cross sections of the trunk and the lower boundary of Ina basin and at ending narrow paths of principal tributaries. In combination with Sakuma dam in the lower reach, they enabled hydro-power utilization in the river basin as a whole.

1-4. Flood control

The upper Tenryu reach, with a relatively independent rift lake on its upstream catchment, runs southward in the tectonic basin whose lower end is held tightly by stricture sections in tectonically rising mountains. The reach retains high sediment production potential compared to other regions of the Japanese Archipelago presumably because it has been mostly intact of volcanic activities and situated in the inland part of the Pacific side of Japan where neither of impacts of glacial abrasion, snow, nor rainfall have been excessive in the Quaternary Period. Thus, both floodwater and sediment washout could become overwhelming with peak discharges seen mainly in upstream sections of geological stenosis, once drastic precipitation phenomena were to take place, although they have not been observed frequently.

The fact that irrigation was not universally available has determined the land use development in Ina basin. As a result, land use has been developed so as to adapt to these natural conditions, rather than to overcome. One of the ways is to adopt successive open levees suitable for unstable meandering channels and to crop while accepting occasional overtopping and retarding along the main trunk of the river.

Dam installation, which was promoted basin-wide in the modern period, changed the capacity of river discharge in the main channel as well as in tributaries, adversarily downgrading rapport at narrow sections, for instance. Human casualties and economic damages of major flood and sediment discharges in the order of historic "Saburoku Saigai (Disaster)" in June, 1961, for example, could have been worsened by these and other facts such as short-sighted land use with poor planning. Basic dimensions of the upper Tenryu reach are summarized in Table-1 below.

Picture: Damages in Ohshika Village in 1961 "Saburoku Disaster" (Koshibu River)

Picture: Damages in Takamori town in 1961 "Saburoku Disaster" (Main channel)

Picture: Damages in Komagane City in 1961 "Saburoku Disaster" (Shingu River, Nakazawa district)

Table-1: Basic dimensions of of the upper Tenryu reach

Characteristics	Dimension	Note
Headwater of the river	Chino city, Nagano Prefecture	Mt. Yatsugatake(Mt. Akadake with the altitude of 2899.2m)
Highest point	3,120m	Mt. Akaishidake, Koshibu river
Drainage area	5090km2	Approximately
Stretch of the main channel	228 km	Including the portion in Lake Suwa, approximately
Max. design discharge	5,700m3/sec	At Tenryu valley datum point
Coefficient of river regime	18-227	At Miyagase datum point, year 2003-2012.
River width	64 - 546m	At high water level
Typical Gradient in the maiin channel	0.5%	or 1/200
Typical Gradient in the tributaries	5% - 20%	or 1/5 - 1/20
Typical size of bed material	3-120mm	Main channel
	30-300mm	Tributaries
Precipitation	118.0mm	Max hourly rainfall, Ushiroyama rain gauge, August 8, 2009
	150.0mm	Max 3-hr rainfall, Ushiroyama rain gauge, August 8, 2009
	346.3mm	Max daily rainfall, Ichida rain observatory, June 27, 1961
	1471.7mm	Averaged annual rainfall from 2003-2012, averaged over observatories
	1072mm	12-month total in the worst drought year (1994), averageed over observatories

2.Socio-economic environment of the upper Tenryu reach seen from geographic conditions: broader networks have supported the regional economy

Each period has had different states and regions with mature culture and prosperous economic activities. Whether it is the structure of political rule or that of economic production, or the combination thereof, that decides how mature their culture and prosperity are, is still under discussion. It appears reasonable to expect that an economy thrives under a less-exploitative ruling regime with well-balanced distribution of resources and reinvestment to production, in concomitance with a production structure not only with land, production capital, and labor but also with sizable technical innovation. History seems to have provided plenty of counter examples, however. Modern social science is full of many useful ideas for analyzing dominant factors and mechanism such as a market based on well-established rules, an efficient hierarchical organization, significance of wider trade conditions, etc. It would be a shorter way to take notice of networks, how regions have been connected and tied, in the first place, for a broader comprehension not only of politics and economy, but of society and ecosystem as a whole. In fact, the economy on the Japanese Archipelago, situated to the east of the Eurasian Continent, has been historically influenced greatly by the Continent and southeast Asia by way of the sea.

The Japanese Archipelago is situated on the eastern edge of the continent in the mid-latitude. Its south and southeast coast, facing northward warm *Kuroshio* ocean current, sees much rain from monsoon climate while the north and northwest coasts see much snow by the lake effect of the Japan Sea, a wide and deep back-arc basin. Fauna and flora of the Japanese Archipelago had seen much transformation and made a diverse ecosystem as a variety of biological species had visited the islands in the Holocene Period. They had come either through connection by land and of thick ice during glacial ages and through maritime connection during interglacial periods.

Likewise, in regard to connectedness and tie, the history on the Japanese Archipelago could be better understood by taking note of the fact that ruling influence of continental civilization has not been unilaterally dominant with the presence of a back-arc basin. The Japan Sea was depressed widely by prominent mantle plumes from underneath. The islands has been accessible from every direction through the sea. The islands certainly found their place in the ancient system of international tribute trading as a peripheral region of the Chinese civilization which had established its political order in the continental plain. Distance between the continent, however, has enabled the islanders to hold a degree of independence. Migration to the archipelago on the eastern border of the continent has been almost incessant since as late as the *ritsuryo* legal code era(7 A.C.), *Heian* era(9-12 A.C.), through the modern era, estimated from fragmented records at hand so far. The reason of migration varied presumably from accidental shipwreck, exploration, flight from political oppression, urge for conquest, on one end, to abduction by ancient Japanese-based pirates (*wakoh*) or coercive immigration by invading forces to the Korean peninsula to the other end. Multiple sources convince us to conclude that, other than officially-recognized diplomatic and trade channels with Min dynasty (and Chin dynasty after the transition) and with the Netherland, exchange contacts in terms of people and goods were not totally suppressed. They were, for example, through illegal trades northward in the Japan Sea and through transit trades southward via *Ryukyu* kingdom even during the so-called national isolation (*Sakoku*) period from the 17 through the mid-19 century. This historic background is compelling enough to think of the Japanese Archipelago as based on the exchanging two-way networks of people and goods, whether it might be regarded as a state or a region, especially after modernization with the development of means of transportation. Large portions of socio-economic activities on the Japanese Archipelago are properly understood as an entity on the global network of human and material exchange, particularly given the present form of cross-bordered economic activities. Preconditions such as security on and around international navigational channels and safety of port facilities from typhoons and tsunamis near coastlines are surely to be met. The economy of The Japanese islands has been blessed with logistical networks much readily tenable than continental countries. People have had access to sea surface transportation, river transportation mainly up to the medieval period, and land transportation by rail and then by automobile from the modern period. Solely favorable as this condition may appear, it has its own caveat as having induced declines of domestic industries as agriculture, horticulture, fishery, and mineral resource mining, to name a few. To that extent, it has been harmful to national land conservation of the Japanese Archipelago in a sense that the land outside urbanized areas has been left uncared after much disruption due to overuse for a long time. It goes without saying that the condition is favorable in giving competitive advantages to many manufacturing sectors. The accessibility is critical to how the map of cooperation and competition among regions is drawn in the long run.

General discussion on international cooperation and competition may suggest that the Japanese Archipelago is not inferior to other regions. The case is, however, different when we turn our eyes on how Japanese domestic regions have been connected and tied.

The Japanese Archipelago saw the emergence of the system of centralized administration, patterned formally after ruling structures in the continental plains, later than other countries. It had also experienced the longer period of distributed and self-sustaining forms of the economy in each region. It is widely accepted and normal to ascribe these causes to the distribution of steep mountain ranges, blocking rapid long-distance transportation. The hypothesis is adequate for the explanation of difficulty of militarily and politically uniting the islands in an authoritative and uniform way by large armies. It can also explain the difficulty of the establishment of an exchange market for bulk goods including daily commodities. It is not, however, suitable for the explanation of human and cultural exchanges among regions that have been accomplished despite time and economic burden needed for transportation nor for the explanation of exchanges of such goods as highly symbolic or of high value added, noble metals and of specialties, though limited in terms of quantities. Many illustrative traces around the islands reveal that people have made cultural, religious, and economic exchanges among the same trades between and among surprisingly far regions through routes and corridors, not excluding mountains.

Mountain ranges and rapid streams, which do not easily allow people to go upstream, are widely seen all over The Japanese islands. The collection of goods by way of going down rivers, nevertheless, was within their reach. As a result, rice and trees which had well-sorted qualities for smooth trade among daily commodities, were collected to political and economic center(s), firstly but not limited to the capitol (*Miyako*), from greater regions in the medieval period and from around the country in the early modern period. These facts lead us to hold that the political and economic connection and ties on the Japanese Archipelago have been so developed, against the blocking, but not complete, terrestrial landforms, that the human society of collected wills, under self-adaptation, has brought forth economic regions which are cooperative in one sector while competitive in the others. Networks of many kinds, rather than of a kind, were weaved out for many layers with interaction, as a consequence of relatively distributed and self-sustaining development of each local economy. Each locality was thought to have a central function in one area, and a marginal function, or a mere path, for another.

As the east and the west of the world have been separated and divided by traffic and transportation cost, including those of time for passengers and goods, so have been those of the Japanese Archipelago by the mountains of Chubu (literally, “central part,” of the Japanese main island, Honshu) that render land transportation geographically challenging. This geographical obstacle of mountains, however, has not been absolutely unsurmountable. Depending on trade fields, or conditions of each period, it has behaved as semi-permeable membrane, obstacles in a case and passages in another, and even provided stages for active intercourse and exchange.

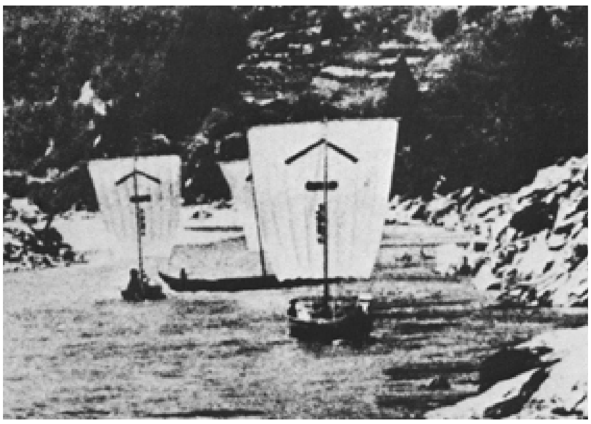
Ina basin, or Ina-dani, as the south part of Chubu mountains, did not act as religious-cultural obstacle during the medieval period. It provided a division line, within itself, between *Tendai* sect of Buddhism on its south with Kouzenji an abri for Hieizan Enryakuji temple of Kyoto, and Sino-Japanese esoteric Buddhism on its north, in the process of spreading through a conciliatory relationship with much-influential Suwa great shrine to the north of the basin. The former was advocated by Saicho of Enryakuji temple, the latter by Kukai of Kouyasan. Ina basin has been under the limitation of agricultural production. Willing or forced, religious donation is dependent on production surplus. The fact that the number of Buddhism temples and Shinto shrines, including other sects, is not impressive in comparison to other regions may be understood from this limitation.

The Chubu mountain range with its highland and hillside has long been a vital region of ranches of military horses together with another region of the northeastern (Tohoku) mountain range. As a result, during the medieval period, the region acted as a major supply source in one case and as an epicenter of a rise in arms, for example, by Kiso Genji, in the other, from a political and military viewpoint. Remnants of Heike at the end of Heian Period,

Picture: Kouzenji Temple (Komagane City)

and Imperial prince Munenaga (or Muneyoshi), disfavored by the political tide, of the Southern Dynasty during Northern and Southern Dynasties Period (1336-1392 A.C.) found their destination in deep eastern mountainsides of Ina basin. The region might be taken as a place of refuge at the period. Afterward, Ina basin provided a path for a march advance at the beginning and a graveyard at the end when Shingen Takeda, reputed as one of the most capable military commander at the end of the medieval period, made his final advancing campaign to the west in 1572 A.C. Main battlefields were outside of the region, in the south, however. The region has never won a central position of control throughout the medieval as well as the modern period, under the limitation of its population and industry agglomeration. It has rather been a subjected area, passively divided by Shogun's demesne with its magistrate's Iijima office in the middle of two feudal domains of Takatoh in the north and Iida in the south.

Turning our attention to the economic domain,



Picture:River Transportation in the upper Tenryu reach (Main channel)

Picture: Misaka Touge Pass
on the ancient Tosendo
(Achi Village, altitude 1569 m)

Picture: Labor-intensive silk industry
in the upper Tenryu reach
courtesy of Okaya Silk Museum

the region used to be a path for sea salt from southern Pacific coast to northern inland from the medieval period. Several documents indicate that Tohyama river basin, in its southern part, provided central pillars for Edo castle tower in the pre-modern period. Large amounts of tree logs, too, were transported out of the basin by rafts through Tenryu river to the south. During the ancient through the medieval period, Tosendo, which runs through Ina basin, was crowned as the major route from eastern regions to Kyoto and Nara capitols. It was, however, replaced by Nakasendo during the Edo period, which won the position of a national corridor between east and west. The shift put Ina basin out of the main corridor and made it less accessible, to its disadvantage.

The Meiji and Taisho period saw the rise of the silk industry in Suwa basin, with easy access to hydropower in the basin, which contributed greatly to national economy. Ina basin supplied plenty of raw materials and fuels of charcoal as its southern hinterland. The modern Japanese history of transportation saw a modal shift from river transportation to railroad, in which Iida railway was laid initially for hydropower industries as a private investment. It was not until the late 20th century, when the central (Chuo) expressway was opened initially in 1975 and 2-wayed in 1985, that Ina basin came to have a full access to national expressway network. The Japanese national economy was so integrated by policy that Tokaido line on southern Pacific coast, later complemented by Tokaido Shinkansen bullet train exclusively for passengers, was chosen as the backbone over Chuo line that penetrates Chubu mountain region. As a result, Ina basin has suffered from disadvantaged passenger traffic and material transportation cost from main economic regions such as Greater Tokyo (Kanto) and Greater Nagoya (Chukyo), to the detriment of its economic integration. The Japanese military regime in the first part of the 20th century prepared aborted works of its last confinement fortress in the area, such as the army airbase in Ina village and the army

Noborito research institute of special covert operations in Nakazawa village (later integrated to Komagane), etc. The region was not, however, chosen as a site of large-scale munition factories most likely because of its remote isolation from major industrial agglomeration. The latter half of the 20^{th} century saw the rise of the Japanese automobile industry as the centerpiece of the Japanese industry agglomeration. They are Mitsubishi group with its origin from pre-WWII period and Toyota group from post-WWII period both in Greater Nagoya Chubu region, Nissan group with its root in southern Greater Tokyo Kanto region, and Honda group originated initially in Shizuoka Prefecture whose present production centers spread from northern Kanto and southern Tohoku region to central Kyushu region. Few automobile parts for the industry are supplied from Ina basin. One of the noted exceptions may be that of Tamagawa Seiki in Iida city, supplying idiosyncratic angle sensors for all the hybrid vehicles. The region is not, by and large, integrated into the major supply chain for the automobile industry. The case is the same for other sectors. Commodities that can compete in the national market are limited to less-weighed and/or high-value goods that can justify and overcome the high transportation cost, such as agar, half-dry confectionaries, and culturally valued decorative Japanese cords made from twisted papers. Ina basin has been detoured by most national networks and put in a secondary position in regard to the economy. Electric power is a rare exception in that the oldest

Picture: Sakuma Dam
the largest hydro-electric power dam
in the entire basin of Tenryu river

frequency conversion station is found in the site of Sakuma dam in the river basin with other 2 facilities closely arranged at Shin-Shinano to the right north and at Higashi-Shimizu to the right south of the basin. Principal hyper voltage power transmission networks that combine the stations run through the upper Tenryu reach with north-south direction. Chubu mountains themselves constitute a vast mountain range which have hindered the entire transportation over the Japanese Archipelago. Ina basin is duly regarded as less integrated to the networks for economic exchanges with insufficient connection and ties, occupying the southern part of Chubu mountains between the Japanese Southern Alps and the Central Alps. It is widely hoped, and expected to some degree, that transportation of goods between Shizuoka and Aichi prefecture to the south will be improved through much tunneled San-en-nanshin Jidoshado (Japan National Route 474) highway by 2020 and that passenger traffic to Greater Tokyo Kanto region and Greater Nagoya Chukyo region through the central magnetic levitation bullet train by 2027. The effect of the improvement on socio-economic environment, however, should not be overestimated optimistically, given the entailing problem of high traffic and transportation costs.

3. Flood control attempted in the upper Tenryu reach

Engineering is a system of technology for solving social problems, not excluding so-called non-structural institutional approaches. Specifically in this context, civil engineering is to be understood as such a system of technology as reducing and mitigating socially undesirable time and space peak phenomena, be they natural or social. Seen from the present network theory, it is expected that civil engineering be conductive to constructing and maintaining networks of infrastructure needed for economy and society, and to shortly reworking in time of such emergency situations as disasters. Application of the definition to the field of flood control leads to the construction and functional conservation of facilities that withstand chiefly peak water discharges in river flood control technology in a strict sense, and peak sediment discharges in sabo technology developed in the Asian/Pacific tectonic zone, most notably on the Japanese Archipelago. Network theory implies that the network of flood river water and sediment is directed and prescribed by topography and the gravity. River flood control technology has a focus on the enhancement of node capacities so that each and every node may contain the transit flow within its capacity every moment as it is the technology to process and to wash out natural floods safely downstream. Sabo technology, on the other hand, has its focus on the reduction of the number of ties to nodes without sufficient capacity as it is the technology to reduce peak sediment discharges, by keeping away rain as well as snowmelt water from coming into mountain hill slopes, for instance.

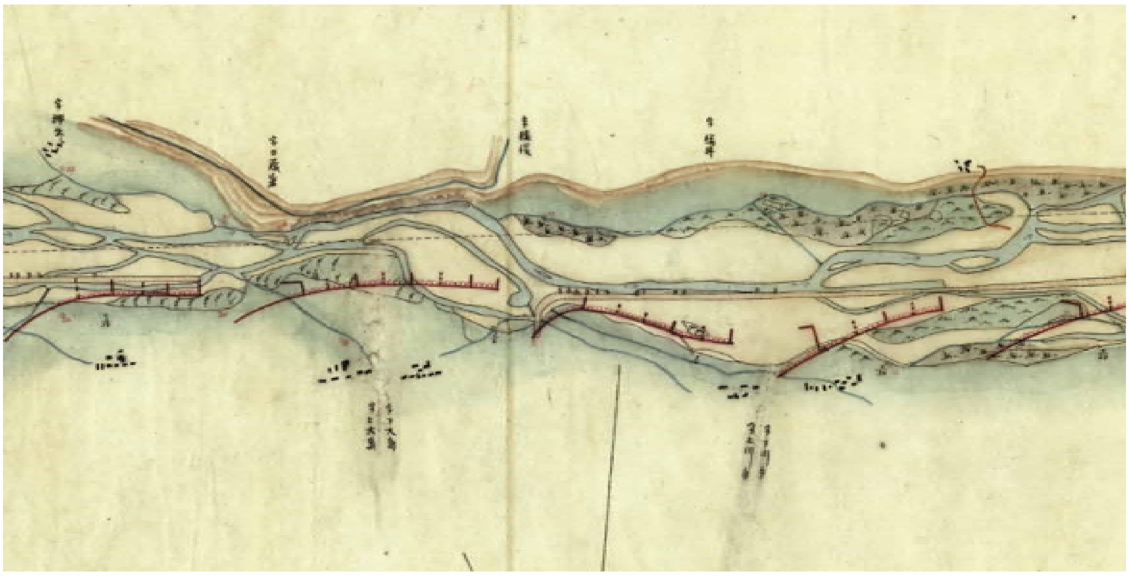


Fig-3: Ancient open levees in the upper Tenryu reach (Mibu river, early Meiji era)
courtesy of Nagano Prefectural Museum of History

Table-2: Historic flood and sediment disasters in the upper Tenryu reach

Year(A.D.)	Name, if known	Category	Principal natural causes	Note
701	Not named	Flood	Unknown	Flood downstream of Takatoh District, the first flood recorded in the river basin.
715	Ikeguchi Failure	Major landslide(~$9.375\times10^7m^3$)	Earthquake (Tohmi Earthquake、est.M=6.5~7.5)	Natural dam(s) formed by landslide(s), came to burst after scores of days. The induced flood brought havoc to present Iwata county, Shizuoka Prefecture, loss of 170+houses and paddy fields.
1533	Not named	Flood	Unknown	Major flood around present Higashi-Haruchika, Ina city, etc.
1624	Not named	Flood	Unknown	Major flood at Tajima village at the time, relocation to tableland of Takatohbara.
1691	Not named	Flood	Unknown	Flood all around the river basin, specifically around Oshika village etc.
1696	Not named	Flood	Unknown	Flood after snowfall, in the river basin.
1715	Major flood of Ram year(Hitsujidoshi)	Flood	Heavy rain(frontal precipitation from june 18-24)	64 houses lost, 33 casualties, nearly handreds parcels of croplands washed at Shimada (present Iida city). Failure induced debris flow at Shimohisakata Kitahara in present Iida city. Lost lives who went to collect flood woods in channels.
1718	Failure of Mt. Morihira	Major landslide	Earthquake (Tohyama Earthquake、M=7.0±1/4)	5 casualties, western parts of Mt. Morihira in Wada, failed. 50+ died by burst flood(s) caused by natural dam(s) in Tohyama river.
1719	Flood of Boar year(Idoshi)	Flood	Unknown	Major flood in the river basin.
1731	Bank lost of Boar year(another Idoshi)	Flood	Unknown	Flood in the river basin.
1742	Major flood of Dog year(Inudoshi)	Flood	Heavy rain(Heavy thunderstorm, not seen for 80 years)	Croplands as well as ancient trees lost in present Minowa town etc.
1755	Flood of Boar year(Idoshi)	Flood	Heavy rain	Flood in the river basin.
1789	Major flood of Bird year(Toridoshi)	Flood	Unknown	Flood in the river basin, left present Ohkubo field, Komagane city, ravaged.
1838	Not named	Flood	Unknown	Flood officials from Edo made a survey around present Ina city.
1865	Major flood of growing Cow year(Kinotonoushi)	Flood	Unknown	Major flood not seen from 1715.
1868	Major flood of May, 18 the first year of Meiji era and July 2, Dragon year	Flood	Unknown	Major flood in the river basin. All the houses inundated, 21 houses and 20+ parcels of croplands washed in Tahara, Higashiharuchika, present Ina city.
1898	Not named	Flood	Typhoon	12 casualties, and 59 houses washed out in Suwa region.
1899	Failure of Mt. Chausu	Major landslide	Unknown	Major flood induced the large-scale failure to Mt. Chausu, blocked Koshibu river. 10 guests died as Koshibu spa washed out.
1907	Not named	Flood	Unknown	Flood in Koshibu river and in the main channel. 3 casualties in present Iida city.
1910	Not named	Flood	Heavy rain	Flood damages caused by heavy rain band around the southern part of Nagano Prefecture.
1911	Not named	Flood	Typhoon	9 casualties.
1923	Not named	Flood and sediment disasters	Heavy rain	Inundation in Iida town, houses lost along Matsukawa, and debris flood(s) at Hinata, Nanakubo.
1945	Not named	Sediment disasters	Typhoon No.10	Damages in Ohshika village by sediment washout: 2 casulaties, roads lost, croplands lost and ravaged. 7 casualties and 20 houses washed out in Kamihisakata village (present Iida city).
1950	Not named	Flood and sediment disasters	Heavy rain	Road blocked, houses inundated, and paddy fields lost at Takatoh and Hase, present Ina city.
1953	Not named	Flood	Typhoon No.2 in June, Depression in July, and Typhoon No.13 in September	Banks and croplands washed out. 7 casualties, 9 missings, 169 injured, 93 houses washed out, and 431 disaster victims.
1957	Not named	Flood	Typhoon No.5	Damages by major flood in the entire river basin, 535 houses damaged.
1959	Not named	Flood and sediment disasters	Typhoon No.7	Damages by Typhoon No.7, 71 houses, roads and bridges lost at Hase, present Ina city. 19 casualties by debris flows in Fujimi town.
1959	Not named	Flood and sediment disasters	Typhoon Ise-bay (No.15)	38 houses totally to severely damaged in present Matsukawa town, 1 casualties and 112 severely-damaged houses in Tenryu village.
1961	Saburoku Disaster	Flood and sediment disasters(465m3/sec, Inatomi Observatory, MLIT), Mt. Ohnishi major landslide	Baiu frontal heavy rain(Total rainfall565mm at Iida weather station)	101 casulaties, 29 missings, 1155 fatally to severely injured, 13953 houses damaged. Mt. Ohnishi major landslide.
1965	Not named	Flood and sediment disasters	Typhoon No.6 in May, frontal rain in July, Typhoon No.24 in September	53 houses totally washed out, 90+ severely-damaged houses, Tohyama Junior High school washed out.
1968	Not named	Sediment disasters	Typhoon No.10	6 casualties and missings, 15 houses totally damaged and 21 severely damaged in Tenryu village. Landslides in Kamimura, Hodono and Funakubo.
1970	Not named	Flood and sediment disasters	Baiu frontal heavy rain	Debris flows and landsilides, croplands lost in Komagane city etc. Economic damages in the basin amounted to about 3.23 billion yen at the time.
1982	Not named	Flood and sediment disasters	Typhoon No.10	Inundation and debris flows in present Iida city, Takatoh and Hase in present Ina city, and Oshika village. Houses, roads, bridges, and croplands damaged. Economic damages in the basin amounted to about 20.4 billion yen at the time.
1983	Flood of September Showa 58	Flood(741m3/sec、Ina observatory, MLIT), Sediment disasters	Typhoon No.10 and heavy rain(Total rainfall282mm, Iida weather station)	6 casualties, 28 injured, and 5203 houses damaged. Damages in the entire river basin.
1999	Flood of June Heisei 11	Flood(696m3/sec、Ina observatory, MLIT), Sediment disasters	Heavy rain(Total rainfall 218mm, Iijima rain gauge)	295 houses damaged, severe damages by sediment discharges in Iida city, etc.
2004	Not named	Flood(836m3/sec, Ina observatory, MLIT)	Typhoon No.23, etc.	Not summarized for specific events.
2006	Heavy rain disaster of July Heisei 18	Flood(1136m3/sec, Ina observatory, MLIT), Sediment disasters	Heavy rain(583mm, Ohtagiri rain gauge, Nagano Prefecture)	About 558 ha inundated, 1076 houses severely inundated and 1465 partially inundated. Road failure of prefecturally admiministered Nakayama-Matsukura, 1 houses partially damaged.

hardly able to justify novel construction investment for large-scale infrastructural networks serving solely for regional economy of the upper Tenryu reach. Tokai and Tohnankai earthquakes expected near future in Tokai and Greater Nagoya Chukyo region, however, could stymy the logistical and energy supply to the regional economy of Ina basin to its devastation. It is, therefore, imperative to lessen expected fatal losses by making an effort to connect to various existing networks and to stretch out newly in alliance with other (sub-)regions.

The upper Tenryu reach has suffered from major floods and sediment discharges once every several decades, though not too often, with the worst sediment production rate on the Japanese Archipelago. Maximal flood discharges can be worsened as natural topographical factors combined with such anthropogenic factors as dam installation for the purpose of water utilization of hydro-electric power, and others. Adaptation has been attempted but thought good enough only for limited planned patterns under the limited justifiable flood control investment, which in turn is capped by the prospective socio-economic development. It makes sense all the more to plan and work together with other public/private projects in the region, which have different purposes, to the extent that the direct flood control investment is constrained financially and fiscally.

Both the main trunk and tributaries of the upper Tenryu reach are already under heavy water and river use for the promotion of stable development of the regional economy. River facilities under the permission of the national administration, even if extracted only for the main trunk, amounts to sizable numbers by category: 2 large-scale dam facilities over the height of 15m (legal threshold), 20 smaller dam facilities with other water utilization purposes as hydro-electric power intakes and crop irrigation, 63 bridges, and 244 various sluice gates installed within the riverbank. Summing up for all the tributaries, the number of man-made structures is almost innumerable. It is not beyond our imagination that these facilities can act as roadblocks against flood and sediment discharges, whose peak loads ought to be reduced for safe and smooth runoff. Historic flood and sediment disasters in the river basin are outlined in Table-2. Few would be entirely free of the anthropogenic influence. The upper most Lake Suwa region has often suffered from inundation damages. It comes partly from the fact that discharge out of Lake Suwa cannot be increased without causing unbearable damages along the main channel downstream. The gridlock of discharging capacity at the lower end of Ina basin affects backwardly to the upper most area, a typical example of river system connectivity, which is a notable characteristics of the upper Tenryu reach.

Basics for better safety of the river basin, without downgrading the utilization, are reinforcements of river embankment mainly along the main trunk for safe and sure flood runoff on one hand, and installations of sabo dam facilities to reduce the rise of main trunk riverbed and to concomitantly mitigate overflowing around tributaries on the other. The river has seen the installation of several large-scale flood control facilities, which requires due care to reduce their side effects (Fig-4). Miwa dam in tributary Mibu river, dated its operation back to 1959, Koshibu dam in Koshibu river to 1969, Matsukawa dam in Matsukawa river to 1975 are all conductive to reduce both flood discharges and the rise of riverbed in the main trunk. Their sediment bypass tunnels are going to put into operation as early as 2016, which have been planned for mitigating dam sedimentation in their own reservoirs. Ground level raising of a notable scale was finished in 2002 in cooperation with private sectors, which provides vital protection against not solely river flood, but also inundation at the back of the banks in a southern section, Kawaji-Tatsue-Tatsuoka. Many as they are, dam facilities which cut across the river channel are not the panacea in reducing flood and sediment discharges and can sometimes have undesired effects as a double-edged sword. The safe protection of the upper Tenryu reach is, therefore, dependent upon the river channel capacity kept at a proper level and bank embankments well-maintained, not less than other rivers on the Japanese Archipelago. There arises the flood control policy of the upper Tenryu reach. First and foremost, a code of sediment discharge management has to be sorted out in working relationship with dam facility managers in order to ameliorate the loss of flood discharge capacity coming from the greatest sediment

Source: Brief History of National projects on sabo works

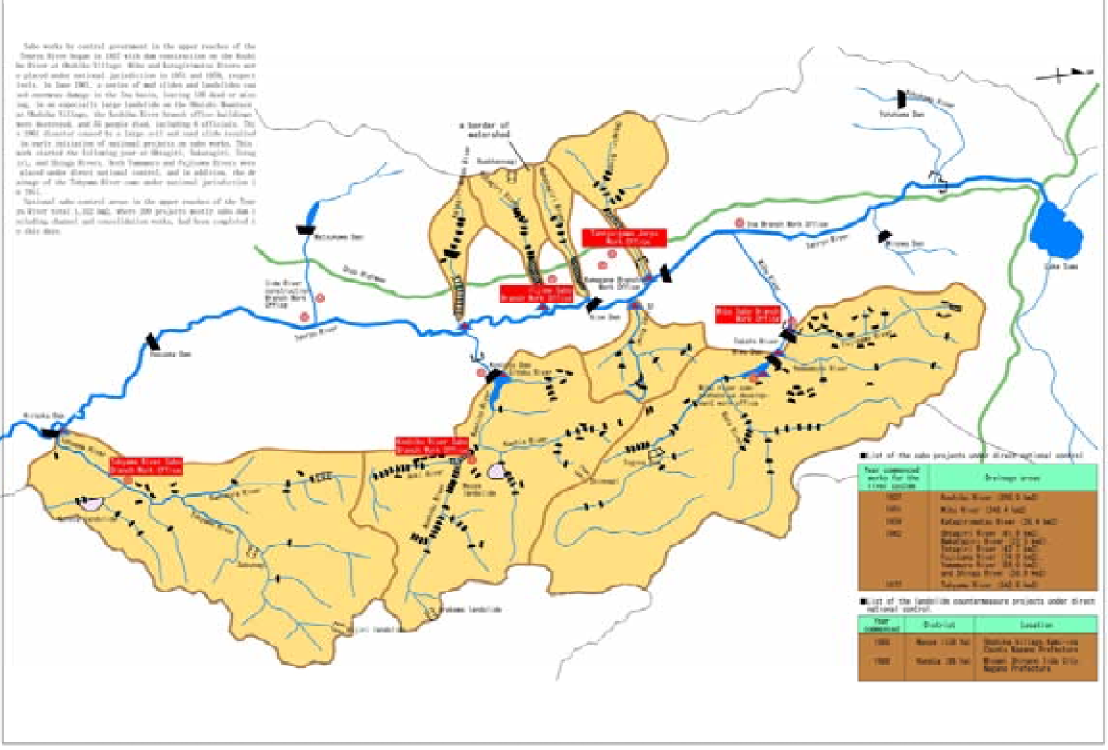


Fig-4: Flood control facilities in the upper Tenryu reach

production seen on the Japanese Archipelago. Second, levee banks have to be protected from damaging hollowlose caving induced by water seepage as the river basin topography makes unbearable the amount of ground infiltration to the banks to its detriment. Groundwater infiltration, together with the immensity of related facilities, has pushes up the bank maintenance expenditure to a considerable order. The safe protection has to be kept even under the pressure of public expenditure cut. Bank structures have to be improved and renovated, together with other major undertaking seen in the river basin, into a type of structure needed less maintenance expenses. Third, flood wood disasters have to be contained pre-cautiously, especially in tributaries. Forests in the basin have been left uncared and/or under poor management for decades. Complex disasters are to be foreseen as sediment discharges by heavy rainfall can be augmented and worsened by plethora of flood woods. Sediment-related disaster alerts based on precipitation indices have been developed nationwide since 2008 for better early warning and evacuation. Another kind of warning such as a large-scale landslide detection system, too, is under development which can be put into use as early as 2016. Evacuation and security of traffic in heavy rains and/or in mid-night remain a daunting challenge, however, given the lack of safe evacuation shelters and the aging population of the basin. It is, therefore, necessary to be cautious in expecting too much for the effects of the early warning and evacuation.

As of February 2014

Written by Dr. Hiroaki NAKAYA, Director General

Tenryu River Upper Reach Office, Chubu Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, JAPAN

Uwabu-minami 7-10, Komagane City, Nagano Prefecture JAPAN 399-4114

http://www.cbr.mlit.go.jp/tenjyo/index.htm

1961:Saburoku Disasters
(Matsuo-shimohisakata,Iida City)

1961:Saburoku Disasters
(Ohshika Village)

Tenryu River Upper Reach Office
Uwabu-minami 7-10,Komagane City,Nagano Prefecture JAPAN 399-4114
Tel:0265-81-6411 Fax:0265-81-6419