# Sustainability of Railways through Disasters and the Roles of Governments

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## Abstract

Recently Japan is suffering from many natural disasters. This paper focuses on those natural disasters' consequences on railways. Railways are very large scale infrastructure and they are very durable. This also means that once damaged they need a large amount of investment for repairs. With the depopulation trend in Japan, especially on rural sides, damages to railways create a great deal of troubles and uncertainty for the future. This paper overlooks the legal systems for the recovery from natural disasters of railways in Japan and examines cases of strikes by natural disasters, earthquakes and floods, in Japan. This paper shows that public supports have been inevitable for many of such incidents and proposes to add environmental consideration to the list of factors giving legitimacy to public supports.

Key Words: Railway, Natural disaster, Japan, Earthquake, Flood

## 1. Introduction

The heavy rainfall in the summer of 2020 inflicted severe damages to many areas including Kumamoto prefecture on Kyushu Island, and many railway lines were affected, with railway bridges of JR Hisatsu Line, JR Kyudai Line and Kumagawa Railway Company being swept away. Seen from the viewpoint of railway business, recent natural disasters mostly happened to railway lines on rural sides, which generally suffer from low profitability.

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The Act on Improvement of Railroads and Rail Tracks, which is the major act about railway construction and maintenance, provides that, as a general rule, the railway operator is solely responsible for the restoration of the railway from natural disasters. However, the act also provides that if a railway meets some conditions, the central government bears, at maximum, a quarter of the cost of rehabilitation and also the local governments bear the same amount but still the remaining part must be borne by the railway company. The conditions are that the amount of damage is more than 10% of the business income of the railway company, and the railway company must have been making loss for three consecutive years prior to the disaster, or the railway company is expected to make losses for five coming years due to the cost of reconstruction. Otherwise the subsidies shall not be given. The amendment to this act in 2018 opened some further possibilities for railways with low profitability to receive public support if they fulfil certain other conditions but, even on such occasions the railway operators are required to bear half the cost of reconstruction.

This paper reviews the processes of restoration of damages inflicted by natural disasters on railways in Japan after 1990s and explores the possibility of giving pivotal role to the environmental superiority of railways at the time of screening the railways to be supported by the public fund.

## 2. Examples of Natural Disasters on Railways and the Process of their Restoration from 1990 to 2010

### 2.1. Hansin-Awaji Great Earthquake (1995)

This was an earthquake which occurred at 5:46am on January 17, 1995. The epicenter was in the northern part of Awaji Island, which lies to the southwest of Kobe area. Its Richter Scale magnitude was 7.2 and by Japanese Seismic Scale it was classed as 7. It was the first example of this classification[1]. The damage was grave with 6,434 dead and 43,792 injured. 104,906 buildings were destroyed and 390,506 buildings were damaged.

The earthquake occurred early in the morning and fortunately bullet trains had not started yet. There were not very many trains in operation but still thirteen trains were derailed. Six of them were the trains of JR West, three of Hankyu, two of Hanshin Electric Railway and one each of Kobe Kosoku Railway and Kobe Portliner. In total there were 1,075 passengers onboard those derailed trains but it was worth noting that none of them were fatal casualty[2].

**Fig.1. Rokkomichi Station (JR-West)**

**Fig.2. Train on its side in Takatori Workshop (JR-West)**


**Fig.3. Itami Station (Hankyu Railway)**

**Fig.4. Derailed trains near Shinzaike Station (Hanshin Electric Railway)**

**Fig.5. Daikai Station (Kobe Rapid Transit Railway)**

**Fig.6. Collapsed tunnel near Nagata Station (Kobe Electric Railway)**

**Source (Fig.1～Fig.6) : Web Site of 'Memories of January 17th Hanshin-Awaji Great Earthquake' http://kobe117shinsai.jp/**

**Table1. Status of resuming operation**

| Railway Company | Date of resuming operation | Note |
|---|---|---|
| JR-West(Shinkansen) | 4/8 | |
| JR-West (Suburban Train) | 4/1 | |
| Hankyu Railway | 6/12 | Itami Station was temporarily restored in March 1995. Completely restored in November 1998. |
| Hanshin Electric Railway | 6/26 | |
| Sanyo Electric Railway | 6/18 | |
| Kobe Electric Railway | 6/22 | |
| Kobe Rapid Transit Railway | 8/13 | Daikai Station was restored in January 1996. |
| Kobe City Transportation Bureau (Subway) | 2/16 | Sannomiya, Shin-Nagata and Kamisawa Station were restored in March 1995. |
| Kobe New Transit (Port-Liner) | 7/31 | |
| Kobe New Transit (Rokko-Liner) | 8/23 | |

Table 1 shows the date of resumption of railway operation on lines near Kobe. JR West could start operation after two and half months because it could receive help from other JR companies and it reused some of the collapsed materials to repair damaged elevated tracks. Kobe City Transportation Bureau was a relatively new railway (subway) and its facilities were newer, which limited the degree of damage. By leaving the restoration of three most damaged stations until later, it resumed operation in about a month. Other railway lines took from five to seven months to resume operation. Damaged elevated tracks were reconstructed with a speed three times more than usual time by working night and day.

**Table2. Damage inflicted on railway Operators**

| Railway Company | Restoration cost (A) | Amount of reduced income (B) | (A+B) | Operating income of Railway Business (April 1993-March 1994) |
|---|---|---|---|---|
| JR-West | 1,020 | 520 | 1,540 | 1,285 |
| JR-Freight | 17 | 104 | 121 | 18 |
| Kobe City Transportation Bureau | 42 | 12 | 54 | 28 |
| Kobe New Transit | 34 | 31 | 65 | 1 |
| Kobe Rapid Transit Railway | 140 | 35 | 175 | 8 |
| Hankyu Railway | 440 | 21 | 461 | 109 |
| Hanshin Electric Railway | 457 | 17 | 474 | 34 |
| Sanyo Electric Railway | 54 | 20 | 74 | 9 |
| Kobe Electric Railway | 87 | 18 | 105 | 21 |

**Cost: 100 million yen**

It is not difficult to see that the amounts of damage to railway operators were considerable. As is shown on Table 2, it took JR West, the biggest sufferer, 102 billion Yen to restore facilities and trains. Also, the amount of unrealized income due to suspension of operation for two and half months amounted to 52 billion Yen. The total loss amounted to 154 billion Yen. This amount far exceeded the total business profit of JR West in the preceding year, FY 1993, 128.5 billion Yen.

JR Group companies normally changes train operation schedules in March every year, and in that year it was planned on March 16th, but it was postponed until April 20th, partly because a railway coach manufacturer located in Kobe was damaged and their production was delayed.

The resumption of operation of JR West's ordinary lines in Kobe area was on April 1st but the operation of private[3] railways were resumed much later. Hanshin Electric Railway and Hankyu Railway both restarted operation in June and Kobe Rapid Transit Railway, on which trains from Hanshin Electric Railway and Hankyu Railway operate restarted its operation only in August.

Before the earthquake, generally speaking, between major cities in Kansai region, train fees of private railways were cheaper than JR West's but JR West trains took shorter time. JR West recovered first and it increased the number of trains so that it could facilitate the passengers of suspended private railways.

This made JR West's service better and many of those private railway users who had no other option than using JR West never returned to the private railways even after those private railways resumed their operation.

The amount of damage of Hankyu Railway was 46.1 billion Yen and the amount for Sanyo Electric Railway was 7.4 billion Yen. Both these figures far exceeded their business profits of the preceding fiscal year (Business Year 1993), and together with the loss of passengers to JR West mentioned above, they made the financial strength of these companies much worse.

Also, the Hanshin Electric Railway had 126 train coaches out of the total of 314, or 41.1% of them damaged by the earthquake. 41 of them were total losses. The depot also suffered damage and although train operation was started in June, 1995, it was not until March, 1996 that full operation was resumed with the repair of damaged coaches, construction of substitute coaches and reconstruction of depot completed. Before that, operation was only with reduced number of trains. Adding to this, Hanshin Electric Railway also lost a large chunk of passengers to JR West and financial damage due to this fact was not light.

As the author mentioned earlier, the Act on Improvement of Railroads and Rail Tracks provides for the cases where a railway operator can receive public support for the restoration of the railway from natural disasters. The amendment to this act in 2018 opened more possibilities for railways with low profitability to receive public support if they fulfil certain conditions but, even on such occasions the railway operators are required to bear, at least, half the cost of reconstruction.

The conditions for a railway operator to receive public support of maximum 50%, shared equally by the central government and local governments, for reconstruction at the time of Hanshin-Awaji Earthquake in 1995 were that the amount of damage is more than 10% of the business income of the railway company, and the railway company must have been making loss for three consecutive years prior to the disaster, or the railway company is expected to make losses for five coming years due to the cost of reconstruction. Because they did not meet the condition of the total amount surpassing 10% of its business income, JR West and Hankyu Railway were not given public support. Support given to other railway companies was much smaller than the maximum, 50%. In the case of Hanshin Electric Railway, the public support was 7.5% of the direct damage and in the case of Sanyo Electric Railway the comparable figure was 16.7%. (cf. Table 3)

The expressways also suffered a severe damage. Hanshin Expressway Authority[4] had damage worth 220 billion Yen. Basically, the Authority was

supposed to pay for the reconstruction with support from the central government and constituent local governments. However, with the reason that "the damage was huge" all the cost of reconstruction was borne by government sector, 80% by the central government and 20% by the local governments. This makes a sharp contrast with the public support to railway companies, which were similarly severely damaged.

**Table 3. Railway Companies that Received Public Supposrt**

Cost: 100 million yen

| Railway Company | Amount of Damage (Direct damage and loss of Expected Income) | Support from the Government |
|---|---|---|
| Hanshin Electric Railway | 474（457+17） | 34 |
| Sanyo Electric Railway | 74（54+20） | 9 |
| Kobe Electric Railway | 105（87+18） | 21 |
| Kobe Rapid Transit Railway | 175（140+35） | 35 |
| Kobe City Transportation Bureau (Subway) | 54（42+12） | 10 |
| Kobe New Transit (Port-Liner & Rokko-Liner) | 65（34+31） | 9 |
| JR-Freight | 121（17+104） | 3 |

### 2.2. The Case of JR West Kuzuryu Line Damaged by Flood in July, 2004

The "Fukui Heavy Rain" in July, 2004 was caused by the southward move of seasonal rain front which also caused heavy rain later named "2004 Niigata Fukushima Heavy Rain," in Niigata Prefecture and Fukushima Prefecture from July 12th to July 15th of 2004. Unusually heavy rain fell in the areas of Fukui City, former Miyama Town (later merged with Fukui City), and Ikeda Town.

Especially, the monitoring post in Miyama Town reported precipitation of 87mm per an hour from 5am to 6am on 18th of July, 2004 and the total precipitation in that day amounted to 285mm. This amount even surpasses the average precipitation in whole July in the area and considering the fact that most of the rain fell in the four hour period from 5am to 9am, it was truly an exceptional rain. In Fukui City, the monitoring post recorded precipitation of 75mm per an hour from 9am to 10am of that day. This timing coincided with the heavy flow in Asuwa River, caused by the heavy rainfall in the area upriver earlier in the morning, which flows down from Miyama City to Fukui City. Due to

this synchronized rainfall, the water level at Tsukumo Bridge in the central area of Fukui City recorded seven meters, which was above the warning level at a little past 9am and three hours later, reached ten meters a little after noon.

The Asuwa River flows through the southern area of Fukui City from the east to the west. There is a point just a little upriver of the central area of Fukui City where the river makes a right turn. The left hand side river bank collapsed there at 2pm of the day. The central part of Fukui City lies on the right hand side of the river and so escaped the flood damage, but on the left hand side of the river, more than 11 thousand buildings and houses were flooded.

According to a survey, this collapse of river bank and resultant flood was not expected by most residents, because Fukui City had not been hit by floods for forty years since the time of "Okuetsu Heavy Rain" in 1965 and the rain had almost stopped at 10am of the day[5].

JR Kuzuryu Line is a local railway that runs along the Asuwa River and it starts from Echizen-Hanandou Station in Fukui City and goes through former Miyama Town, Ono City, and finally reaches Kuzuryuko Station. Its length is 52.5km. The original plan was to extend it to Mino-Ota station in neighboring Gifu Prefecture. This would have made it a line with 150km length. Construction started from both Fukui and Gifu sides and by 1972, most parts were completed except for the part of 25km at the border area. However, due to deteriorating financial situation of the JNR (Japan National Railway) at that time and the fact that not much need was expected both in passengers and freight, the construction was stopped in 1980 and it was never resumed.

In 1968, JNR at that time made a plan to abolish loss making lines and Kuzuryu Line was pointed out as one of the candidates. However, Kuzuryu Line was saved. The reasons were that the area the line serves is a known area of heavy snowfall and that National Road, Route 158, which runs parallel to the line was not well constructed at that time. In April, 1987, the line was transferred to JR West due to the division and privatization of JNR. The decline in the number of passengers has ever been present and the number of passengers in 2013 was only 36% of the figure in 1987.

At the time of the "Fukui Heavy Rain" the line was heavily damaged. Especially, in the part of 9km from Ichijodani Station (Fukui City) to Miyama Station (Former Miyama Town), five bridges out of the total of seven were swept away.

The cost of reconstruction was estimated at four billion Yen including 3.4 billion Yen for the reconstruction of those bridges. Due to the fact that JR West is

a profit--making company, according to the national scheme laid out by the act, JR West had to bear all the cost of reconstruction. However, since Kuzuryu line was a loss-making line JR West did not want to bear all the cost.

After negotiations, it was agreed in June, 2015 that of the 3.4 billion Yen needed to reconstruct the bridges the central government would bear two billion Yen, and the Fukui Prefectural Government would bear one Billion Yen. The reconstruction works started in October, 2015 and the operation restarted in June, 2017, after three years of suspension. JR West bore 0.4 billion Yen for bridges and together with the cost of other reconstruction works JR West bore one billion Yen, a quarter of the total cost.

**Fig.7. Broken bridge (Asuwa Dai-3 Bridge)**

**Source: "Assessment of Disaster Damages in 2005" pp17**

This public support of three quarters of the reconstruction cost was exceptional and what lay in the background of this was the experience of the failure of substitution by bus in June, 2001, when Keifuku Electric Railway was ordered to suspend train operation by the Ministry of National Land, Infrastructure, Transport and Tourism.

In 2001, Keifuku Electric Railway was a private railway company which operated three lines in the northern area of Fukui Prefecture. They ran through Fukui City, Eiheiji Town, Katsuyama City and Sakai City. The total length of these lines was 59km. Keifuku Electric Railway wanted to abolish part of its train network, totaling 22km due to unavoidable loss from operation. Fukui Prefecture and cities and towns along the lines wanted these lines kept and

granted one billion Yen in total from 1998 to 2000.

However, the situation did not improve and Keifuku Electric Railway kept negative attitude toward investment on facilities for safety and the existing facilities themselves were deteriorating. In this situation, in December 2000, an electric train coach, whose brake entirely broke down, collided head on to another coach. The train driver was killed and 24 passengers were injured. Half a year after that on June 24th, 2001, a train driver ignored a stop signal and caused another head on collision. Fortunately, there were no fatal casualty but 25 passengers were injured.

Two head on collisions in half a year was unheard of and the Ministry in charge, the Ministry of National Land, Infrastructure, Transport and Tourism ordered suspension of operation on all three lines from the next day. Passengers were transported by buses. However, the road conditions along the lines were not good. It occurred frequently that to cover a distance which had required fifty minutes by train required more than three hours. Buses were delayed, not as roomy as train coaches and consequently not as comfortable. As a result many people switched to private cars. This in turn made road congestion worse.

It was estimated that to improve safety facilities and other obsolete facilities would take more than 10 billion Yen but Keifuku Electric Railway Company did not have the financial capability to make that much investment. The company expressed its intention to abolish all its railway lines in October, 2001.

Local governments along those lines negotiated among themselves and one of the lines, 6km long was decided to be substituted by bus operations. Remaining two lines, whose length totaled 53kms were transferred to a third sector company[6] named "Echizen Railway Company" which was created by local governments along the lines and private companies of the place. The operation of these two lines was resumed in 2003 by this new company.

In the case of JR Kuzuryu Line, even though the number of passengers was comparatively smaller compared with the case of "Keifuku Electric Railways," the road condition along the line was similarly bad and local governments' and local people's wish for the secure transport in snowing winter was obvious. This made the atmosphere to allow public spending for keeping a railway line.

For Ono City, Kuzuryu Line is the only railway line in the city and the city had been trying to promote the use of the line even before the "Fukui Heavy Rain." After this incident it reinforced its effort. Now the city government is giving subsidies to its residents when they buy seasonal tickets or coupon tickets, or when they use the train in a group of more than four.

**Table 4. Subsidies to the residents of Ono City**

| Kind of Ticket | The provision rate of the Subsidy |
|---|---|
| Group Ticket (More than 4 people) | 50% |
| Coupon ticket (11trips) | 30% |
| Student / Commuter pass | 20% |

## 3. Expansion of the Scope of the Public Support by the Amendment to the Act on Improvement of Railroads and Rail Tracks in 2018

The Act on Improvement of Railroads and Rail Tracks was amended in 2018 and in August, 2018, following the amendment to the act, "Cabinet Order for the Amendment to the Cabinet Order for the implementation of the Act on Improvement of Railroads and Rail Tracks" was put into force. As a result, even a profit-making railway operator may now apply for the public support for the reconstruction from natural disaster, if it satisfies following conditions.

1 The cost of reconstruction exceeds the annual income from the line.
2 The line has been making loss for three past years.
3 The disaster that caused the damage is either appointed as "Severe disaster" or one comparable to it.
4 A plan to secure operation in the long run is established. (This is to avoid the possibility of abolishment soon after receiving public support for reconstruction.)

If this system had existed in 2008, public support according to this system would have been applicable to JR Kuzuryu line. However, the basic scheme that the central government bears 25%, local governments 25%, and railway operator still has to bear 50% was not changed and the ratio of support was still not improved.

To discuss this matter, it is unavoidable to refer to the amendment to the Railway Business Act in 2000. Before this amendment, abolishment of a railway line required approval by the central government. In practice, the approval of the central government was not given without the consent of the local governments concerned. However, this amendment made it possible for a railway operator to abolish a line unilaterally just with one year's notice. As a result, in the period from 2000 to 2011, 1.3 times more lines with 2.13 times more length were

abolished compared with the period from 1987 to 1999[7].

Among those abolished, enumerated in Table 5, are those abolished because of severe disaster.

**Table 5. Railway Lines Abolished due to Severe Disasters**

(from 2000 onward)

| Route | Location Prefecture | Abolished year | Cause |
|---|---|---|---|
| Takachiho Railway | Miyazaki | 2005 | Typhoon |
| JR Iwaizumi Line | Iwate | 2010 | Landslide |
| JR Kesennuma Line (Yanaizu – Kesennuma) | Miyagi | 2011 | Earthquake & Tsunami |
| JR Ofunato Line (Kesennuma - Sakari) | Miyagi , Iwate | 2011 | Earthquake & Tsunami |

At the time of Tohoku Earthquake and Tsunami in 2011, railway lines along the coast were damaged and some recovered from it while others were abolished.

"Sanriku Railway", a third sector railway company in Iwate Prefecture operated two lines, South Riasu line from Sakari to Miyako and North Riasu Line from Kamaishi to Kuji. Both were severely damaged and the cost of reconstruction was estimated at more than 10 billion Yen. This railway company took over the operation of these lines from the JNR in 1984 but had been making loss since 1994. Public support based on the Act on Improvement of Railroads and Rail Tracks at that time was applicable to it, but the railway company could not afford to pay the half of reconstruction cost. At first, these lines looked near to abolishment but in the end the central government bore all the cost of reconstruction and these lines were repaired[8].

On the other hand, three lines of JR East, Kesennuma Line between Yanaizu and Kesennuma, Ofunato Line between Kesennuma and Sakari, and Yamada Line between Miyako and Kamaishi, were also severely damaged but because JR East Company was making profit, public support was not applicable. The damage was very grave and, for example, Kesennuma Line which had a length of 55.3km had nine out of fifteen stations in between terminals swept away.

The cost to reconstruct the tracks to its original form was estimated at 30 billion Yen and JR East had the intention to bear it. However, in the grand design of the recovery of the area, urban planning in the area along the railway line was greatly reviewed and the line was required to move to higher places which were considered immune from Tsunami. This was estimated to cost additional 40

billion Yen. JR East did not want to invest this additional amount on a loss making line and expressed the wish that this additional cost is borne by the public sector. However, according to the act at that time, it was difficult to give financial support to JR East, which was a profit-making company. Therefore, reconstruction was given up and Bus Rapid Transit System was introduced in its place, partly using the space of old railway track.

Ofunato Line saw a similar development but Yamada Line was different. JR East wanted to introduce BRT as well but local governments and people wanted the reconstruction of the railway. After negotiations, it was agreed that Sanriku Railway, which operates lines to the north and south of it, would take it over and reconstruct it in 2014. At that time, JR East bore all the cost of the reconstruction of railway facilities (14 billion Yen), the central government paid 7 billion Yen for stations and their surroundings. Also JR East contributed 3 billion Yen to local governments along the line. The reconstruction started in 2015 and the operation was resumed in March, 2019.

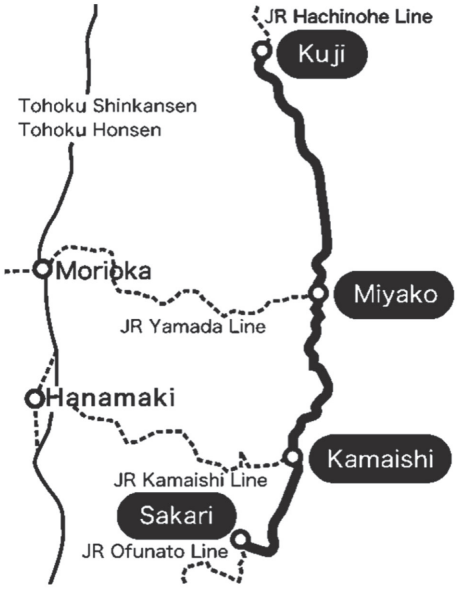


**Fig.8. Route map of Sanriku Railway**

**Source: Website of Sanriku Railway**
**https://www.sanrikutetsudou.com/en/time.html**

## 4. Cases after the Amendment to the Act on Improvement of Railroads and Rail Tracks in 2018

### 4.1. JR Tadami Line

JR Tadami Line is a local railway from Aizu-Wakamatsu Station in Fukushima Prefecture to Koide Station in Niigata Prefecture. Its length is 135km. At the time of heavy rain in July, 2011, it suffered grave damage including the loss of three railway bridges. The operation of the less damaged parts was resumed by the fall of 2012 but the 27km part from Aizu-Kawaguchi Station to Tadami Station in Fukushima Prefecture had no plan for future at that time. This part had had only about 50 passengers a day on average and the financial result in FY2010 showed 335 million Yen was spent to earn 5 million Yen[9]. For this reason, JR East was reluctant to reconstruct the railway line and restart train operation. JR proposed to switch it to bus operation.

However, local governments along the line wanted the recovery of the line, and after negotiations spanning one year in 2016, restoration of the railway was agreed upon with local governments bearing part of the cost in the spring of 2017.

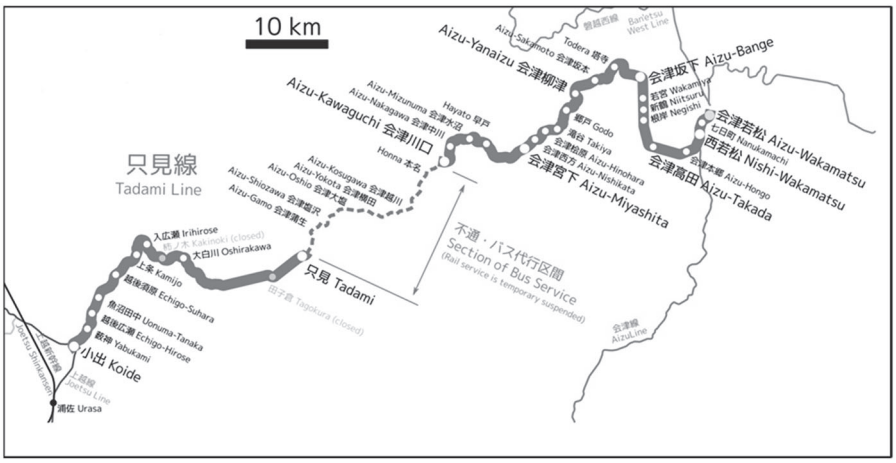


**Fig.9. Route map of Tadami Line**

**【Source】 Wikipedia "Tadami-Line"(In Japanese)**

**https://ja.wikipedia.org/wiki/%E5%8F%AA%E8%A6%8B%E7%B7%9A#/media/%E3%83%95%E3%82%A1%E3%82%A4%E3%83%AB:Linemap_of_Tadami_Line_with_Stations.svg**

The cost of reconstruction was estimated at 8.1 billion Yen. Of this, JR East agreed to bear 2.7 billion Yen. If the current scheme of the Act on Improvement of

Railroads and Rail Tracks had been applied, JR East would have borne around 4 billion Yen. Therefore, JR East was exempted from about 30% of its share. Remaining 5.4 billion Yen was borne by local governments along the line including Fukushima Prefecture. The reconstruction work started in 2018 and resumption of operation in 2022 is hoped for.

Adding to this special financial arrangement, the Vertical Separation System was adopted in this case. This meant here that local governments along the line take the ownership of tracks and other facilities and JR East takes responsibility for train operation. This system has been adopted in some cases in Japan for the purpose of improving economic viability of train operation, but this was the first case for JR East. Railway tracks and facilities are owned by local governments, but since they do not have the technical expertise for its maintenance that actual maintenance is contracted out to JR East.

It was also agreed that local governments would pay 200 million Yen to JR East every year after the resumption of the train operation as the cost of maintenance of railway operation facilities.

Before the heavy rain struck, this part of Tadami line lost more than 300 million Yen every year. So even with the 200 million Yen JR East would receive every year JR East is expected to lose more than 100 million Yen every year. In most cases of vertical separation it is arranged that loss would not be made by the train operator. However, this scheme presumes the loss incurred by the train operator and in that it may be a very special case.

### 4.2. JR Hita-Hikosan Line

JR Hita-Hikosan Line is a local line linking Jono Station in Fukuoka Prefecture with Yoake Station in Oita Prefecture. Its length is 68km. In old days, it transported a large quantity of freight like coal and limestone. However, with the closure of coal mines and switch to trucks, those freights are gone and the number of passengers was also declining. In 1987, the line transported on average 665 passengers in a day but in 2016 the comparable number was 131, a decline of 80%. In 2016, the cost of operation was 293 million Yen and the line earned 28 million Yen, making a huge loss.

At the time of "Northern Kyushu Heavy Rain" the operation of the part from Soeda Station in Fukuoka Prefecture to Yoake Station, which accounts for 40% of the length of the line was stopped due to severe damages to the track. Since the line was only making loss, the plan of recovery was slowly compiled and in April, 2019, JR Kyushu publicized the result of its investigation.

JR Kyushu estimated that reconstruction work would take 5.6 billion Yen. The proposal of the JR Kyushu was that it would reconstruct the railway if local governments along the line would contribute a quarter of this cost based on the scheme of the Act on Improvement of Railroads and Rail Tracks plus yearly payment for operational cost of 160 million Yen, beside the central government grant of the quarter of the reconstruction cost based on the same scheme. Even with these contributions railway operator, JR Kyushu expected to make a loss of more than 100 million Yen per year. This situation was similar to the case of JR East's Tadami Line.

JR Kyushu also proposed two other alternatives. One was the switch to buses and in this case, travel time is much lengthened from 44 minutes in the case of trains to 69 minutes but only 200 million Yen is needed for recovery works. Yearly operational cost would be 140 million Yen. The other is the introduction of BRT (Bus Rapid Transit System) which uses part of the former track as its own road. In this case, the recovery cost would be 1.1 billion Yen but the operational cost was estimated at 110 million Yen a year and travel time would be 49 minutes, longer than a train but much shorter than a bus.

In the cases of these alternatives, local governments were not expected to support operational cost.

Local governments along the line wanted to keep the railway but they were determined not to share the recovery cost. In July, 2020 JR Kyushu and local governments agreed to give up the reconstruction of the railway and the line would be operated by JR Kyushu as a BRT line solely with its own finance.

In Kyushu, another heavy rain struck in July, 2020 and operation of four lines was suspended due to damages by it. Among them, Kagoshima Line which is a trunk line and used also for freight transport was repaired in one month. The restoration of Kyudai Line in Oita Prefecture took longer but the operation was resumed in March, 2021. However, as the author mentioned earlier, Hisatsu Line had grave damage with two bridges swept away and two stations almost disappearing. The operation of 60% of Hisatsu Line, between Yatsushiro Station in Kumamoto Prefecture and Yoshimatsu Station in Kagoshima Prefecture, 87km, is still suspended. The cost of reconstruction is said to be more than 10 billion Yen. JR Kyushu wants public support, but there has been no progress by now. This part made a loss of more than 800 million Yen in 2018[10], which is on the worse side.

## 5. The Possibility of Considering "Environmental Burden" as a Scale to Measure Effectiveness at the Time of Deciding upon Public Support

Railways have an advantage for mass transport at a cheaper cost. This advantage is not fully realized in sparsely populated areas and quite often this lead to poor profitability. However, railways have other advantages that they put much less burden on environment than other transport measures like automobiles, if measured by per passenger unit. They also have merits in punctuality and safety, which is hard to measure by profitability in a shorter time span. A railway is a system which requires a huge scale of facilities and connected pieces of land. So once abolished to revive it is very difficult. Therefore, abolishment of a railway must be scrutinized beforehand of its appropriateness.

On the other hand, public support for the survival of railways must not be allowed without due justification. Ultimately it must be left to the negotiation between train operators and governments. However, political decisions must be made after as much objective truth is made clear as possible. In this context, it is worth noting that railways have superiority in carbon dioxide emission per a passenger per 1km. In the case of passenger transportation, transporting a passenger for one kilometer produces 19g of $CO_2$ by a railway, while the comparable figure for a bus is 55g according to the data made by the Ministry of National Land, Infrastructure, Transport and Tourism[11]. This means that railways are three times more environment friendly that bus service.

However, these figures suppose operation with full capacity passengers. According to the preliminary calculation the author made, making use of publicized data from transport operators and electricity suppliers, it seems that if an electric train coach is occupied by more than 49 passengers, the emission of $CO_2$ per unit is less than the unit cost shown above, and the same is true when a bus is occupied by more than 14 passengers. This shows that superiority of a railway in environmental consideration depends heavily on the scale of passenger flow. But this also suggests that, since trains with full capacity passengers are three times more environmentally efficient, they can beat the bus with full capacity passenger in this consideration as long as they have more than 17 passengers on board.

The author has been showing the cases of disaster struck railway lines. In

urban areas they were restored in a hurry without questions being asked. But on rural sides, some of them survived but some of them were abolished after being struck by a disaster. It depends on the situation the areas are in but it also depends on political negotiations. The scheme provided for by the act is not always followed, since it is ultimately the will of the train operator that decides the life or death of the line. In all cases, survival was impossible without public supports. All of those lines would never be constructed anew now, with automobiles and depopulation which make it financially unfeasible. But when prolonging their lives is argued other factors may come into consideration. The railway is already there and you do not need construction cost. You need cost of reconstruction and operation including maintenance. Availability to those who do not drive, seniors and juniors, safety, especially safety in snow, punctuality and speed may be among consideration factors. Adding to them, although the superiority of railways to some extent depends on the size of passenger flow environmental consideration may cast light on some of those cases, by showing whether it is environment friendly to keep the railway or not.

## Notes

[1] This Seismic Scale 7 was added in 1949 after the big Fukui Earthquake in June, 1948.

[2] Although there was no fatal casualty among passengers on board, there were three fatal casualties related to railways. One policeman was killed in the police detachment office (Koban) inside Itami Station of Hankyu Railway, which completely collapsed and two residents were killed in their home under the elevated railway track of Hansin Electric Railway between Shinzaike Station and Oishi Station.

[3] JR (Japan Railway) Companies are the results of division and privatization of former Japan National Railway (JNR). They are also private companies but they are, in many aspects, under different regulation from traditional private railway companies. So in usual Japanese context, they are not included in "Private Railway Companies" and this concept is kept in this paper.

[4] Hanshin Expressway Authority was a governmental entity which the central government and local governments jointly established.

[5] cf. "Saigai Rettou 2005 (Archipelago Full of Disasters 2005) " P16 Ministry of National Land, Infrastructure, Transport and Tourism

[6] A Third Sector Company in this context is a company created with contribution from both local governments and private companies.

[7] Masatosi Hatoko and Hisaaki Yamamoto "Analysis on the change in the situation of railway abolishment before and after abolishment of demand and supply adjustment regulation" Assorted Papers by Civil Engineering Academic Society vol. 69 No.5 pp669-676

[8] In a sense, the central government bore all the cost as a symbol of their commitment to the Tsunami Damaged areas.

[9] Railway Journal August 2017 pp11-18

[10] JR Kyushu "Financial results by lines"

[11] "Transport, Traffic and Environment" 2020 Edition pp11

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