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Case Study on Application of Asset Management of Irrigation Infrastructure for Rice Production in Australia

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Abstract

Asset management is a new concept for operation, maintenance, rehabilitation, and reconstruction of irrigation infrastructure taking into account economic assessment of trade-offs between alternative investment options to help make cost-effective investment decisions. In most countries including developed and developing countries this concept is required mainly due to the lack of financial support from the public sector. In this study, asset management of irrigation infrastructure implemented by corporatized or privatized organizations separated from the state government of New South Wales (NSW), Australia are reviewed to find out essential issues for appropriate asset management of irrigation infrastructure. The viewpoint of business management, discount rate, lifespan of assets, and deterioration forecast are the essential issues for efficient asset management.

Discipline: Irrigation, drainage and reclamation
Additional key words: business management, deterioration forecast, discount rate, lifespan of asset

Introduction

In most countries including developed countries such as Japan and Australia, as well as developing countries, the actual investment fund is generally less than the necessary fund for appropriate operation, maintenance, rehabilitation, and reconstruction of irrigation infrastructure mainly due to the lack of financial support from the public sector. This causes severe deterioration of irrigation infrastructure, and therefore a new concept of asset management of irrigation infrastructure is needed. Asset management of infrastructure incorporates the economic assessment of trade-offs between alternative investment options, and uses this information to help make cost-effective investment decisions[7] for appropriate operation, maintenance, rehabilitation, and reconstruction of infrastructure by considering infrastructure as assets. Lessons learned from asset management of irrigation infrastructure in developed countries such as Australia should be used for appropriate implementation of asset management in developing countries.

In this study, asset management of irrigation infrastructure implemented by corporatized or privatized organizations separated from the state government of NSW, Australia are reviewed to find out essential issues for appropriate asset management of irrigation infrastructure. In Australia, limited precipitation makes irrigation very important for agriculture, and water management and asset management of irrigation infrastructure are very important for appropriate irrigation. Especially, NSW is one of the advanced states for asset management of irrigation infrastructure as irrigated agriculture is very active in the region of the Murray-Darling Basin.

In this study, the case of asset management of irrigation infrastructure for rice production in paddy fields in NSW, Australia will be compared with the case in Japan, and the advantages and disadvantages of the case in Australia will be identified and used for the implementation of asset management of irrigation infrastructure in Japan and developing countries.

Trends of Asset Management of Irrigation Infrastructure in Japan and Australia

1. Asset Management of Irrigation Infrastructure in Japan and Australia

Asset management is a new concept for operation and maintenance of irrigation infrastructure. In most countries,

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mainly due to the constraints of limited budgets, it is difficult to acquire necessary funds for appropriate operation, maintenance, rehabilitation and reconstruction of irrigation infrastructure. Asset management is a new concept to extend the life-span of irrigation infrastructure and reduce life cycle costs with preventive rehabilitation.

Australia has been adopting asset management of irrigation infrastructure especially for rice production in paddy fields while Japan has just adopted asset management of irrigation infrastructure. Therefore, this study reviews asset management in Australia comparing it with the case in Japan.

2. Japan

Asset management of irrigation infrastructure in Japan has just started mainly due to the recent severe lack of governmental funds for appropriate operation, maintenance, rehabilitation, and reconstruction, which are required to extend the lifespan of irrigation infrastructure with preventive rehabilitation and reduce the LCC (life-cycle cost). The Guideline of Asset Management of Irrigation Infrastructure[3] was drawn up by the Rural Development Bureau, the Ministry of Agriculture, Forestry, and Fisheries in March 2007, and administrative activities and research in asset management have just started. The basic framework of Japan's asset management can be divided into 5 steps as follows[5]: (1) inspecting the current state of infrastructure deterioration; (2) forecasting future deterioration; (3) selecting various rehabilitation and replacement methods; (4) comparing LCCs of the selected rehabilitation and replacement methods; and (5) establishing the most appropriate plan of rehabilitation or replacement method taking into account the whole irrigation system. While the above steps of (1) ～ (4) are implemented for each infrastructure, step (5) should be implemented for the whole irrigation system over an extended area.

Currently only some parts of the above mentioned framework have been implemented, and the whole asset management framework has not yet been fully implemented. Actually, from the administrative viewpoint, the Japanese Government has been implementing inspections of all nationally built irrigation infrastructure since 2007 for a period of 5 years to collect inspection data on infrastructure which would be used for forecasting the future deterioration. From the research viewpoint, most research on asset management focuses on inspection methods and rehabilitation methods. However, methods for forecasting future deterioration are crucial for comparing LCCs of the selected rehabilitation and replacement methods, and establishing the most appropriate plan for the whole irrigation system. Only one example of research for forecasting future deterioration is the forecast of irrigation canal deterioration and joint deterioration[4]. The discount rate for calculating LCCs is set at 4% by the government in Japan.

3. Australia

Asset management of irrigation infrastructure is implemented especially in NSW where there is paddy field irrigation of rice in the southern part of the state (Fig. 1). Rice production in paddy fields consumes much more irrigation water compared with other crops and livestock. Rice is only grown in the southern part of NSW, Australia. Therefore, NSW was selected for this study. Appropriate operation, maintenance, rehabilitation, and reconstruction of irrigation infrastructure are actually called "asset management" in Australia in the English language. Various organizations such as the Federal Government, State Government and separate organizations have different roles and responsibilities for water reform, water management, and asset management of irrigation infrastructure (Table 1). The Federal Government and State Government have no actual responsibility for asset management but have responsibility for water reform and water management. Water reform began in 1994 to significantly improve water management across the nation with a focus on the Murray Darling Basin. Water reform embraces pricing reform based on consumption-based pricing and full cost recovery, the reduction or elimination of cross-subsidies and making subsidies transparent, the clarification of property rights, the allocation of water to the environment, the adoption of trading arrangements, and public consultation and participation[1]. Mainly due to the governmental water reform, various organizations which are responsible for asset management have been separated from the State Government. An organization called "State Water" has responsibility for asset management of huge water-related infrastructure such as dams. Various irrigation limited companies such as Murray Irrigation Limited and Murrumbidgee Irrigation Limited have responsibility for asset management of relatively small irrigation infrastructure such as irrigation channels and drainage canals. Murray Irrigation Limited and Murrumbidgee Irrigation Limited were selected for this study as they have the first and second largest total area in the system among the main five irrigation limited companies in NSW. These irrigation limited companies were historically established as local organizations about 100 years ago, and were incorporated to the NSW State Government before the privatization. Therefore, their irrigation infrastructures were originally constructed before the privatization. The discount rates for calculating LCCs are determined by each organization instead of the Federal or State Governments.

In this study, the research method is mainly field survey. The authors visited NSW, Australia in March 2008, and visited various organizations that have responsibility for asset management of irrigation infrastructure. In addition,

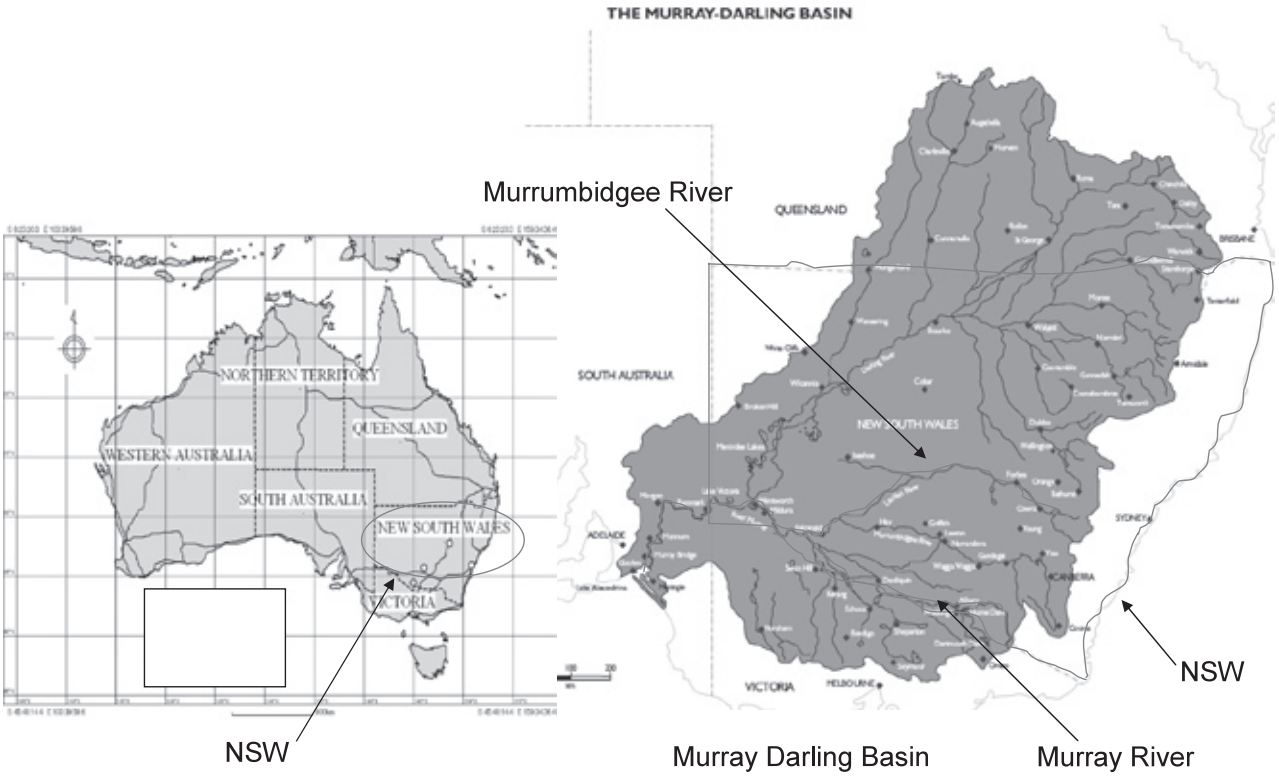

Fig. 1. New South Wales, Australia

related documents have been reviewed to collect more detailed information.

Table 1. Various organizations' responsibilities for asset management

Organizations	Main responsibilities
Federal Government	-determining water reform
State Government	-overall water management -water licensing and trade -water sharing plans -providing water for the environment
State Water	-delivering rural bulk water to irrigation limiteds and other organizations -operation and maintanence of dams, weirs and regulators to deliver water for town water supplies, industry, irrigation, stock and domestic use, riparian and environmental flows.
Irrigation Limiteds	-delivering irrigation water to farmers -operation and maintanence of irrigation channels and stormwater escapes and other structures

Asset Management of Irrigation Infrastructure in New South Wales

1. State Water

State Water was corporatized and separated from the NSW State Government in 2004, according to the State Water Corporation Act[8]. State Water is NSW's rural bulk water delivery business, annually delivering on average 5.5 billion m^3 of water to regional NSW, along 7,000 km of rivers. State Water also delivers on average, about 9.0 billion m^3 of water for the environment in accordance with water sharing plans. Water sharing plans are determined by the State Government. State Water manages and operates 20 dams and more than 280 weirs and regulating reservoirs to deliver water for town water supplies, industry, irrigation, stock and domestic use, and riparian and environmental flows. One of the main dams operated by State Water is Burrendong Dam. Burrendong Dam's storage capacity is 1.12 billion m^3. The water level is very low due to the severe drought (Fig. 2). State Water employs more than 300 people who operate from 43 offices throughout NSW and work closely with water users and Customer Service Committees to set asset management priorities and improve water delivery efficiencies in regulated river valleys.

In accordance with the State Water Corporation Act,

Fig. 2. Burrendong Dam operated by State Water
Photographed by the author in March 2008.

State Water has several responsibilities in asset management. State Water must ensure that its assets are managed in a manner consistent with the lowest life cycle cost and acceptable risk of the assets, the whole life of the asset, and its assessment of the risk of loss of the asset and capacity to respond to a potential failure or reduced performance of the assets. State Water also must report to the Independent Pricing and Regulatory Tribunal (IPART) on the state of each group of assets managed by State Water, including a description of the processes, practices, systems, and plans State Water uses in managing the assets, a description of each group of assets, an assessment of the major issues or constraints on current and future performance of the assets, and the strategies and expected costs of future investments in the assets. IPART is the independent economic regulator for NSW, and oversees regulation in the electricity, gas, water, and transport industries and undertakes other tasks referred to it by the NSW Government.

Expected lifespan of the assets is determined based on engineers' judgments. These engineers' judgments are relatively subjective, and they do not determine the expected lifespan based on more accurate deterioration forecasts. Dams, weirs and regulating reservoirs, and channels and structures such as culverts and causeways have 100-200, 50-100, and 40 years of lifespan, respectively.

The expected future cash flow for asset management is calculated with a net present value method. The net present value is defined as the total present value of a time series of cash flows, and can be calculated with a discount rate[2]. The pre-tax Weighted Average Cost of Capital (WACC) is used to discount future cash flow, taking into account the trends in the private sector's financial market as State Water has been corporatized. It is calculated to determine capital cost with a combination of those capital costs with gains from stock markets and loans from banks to collect necessary funds for investment projects[2]. This WACC is usually used by private companies to calculate capital costs. The discount rates were 9.88% in 2006 and 10.42% in 2007. The calculation periods for the future cash flow were 50 years in 2006 and 85 years in 2007[8]. The discount rate and calculation period are annually determined by IPART.

IPART determines the price for water which State Water provides to its customers, taking into account State Water's expected future cash flow for asset management and customers' payment capacity. In this case, IPART requires State Water to lower the water price by cost reductions and efficient management.

Asset inspections are divided into three stages based on the importance of the assets. Dams, weirs and regulating reservoirs, and channels and structures such as culverts and causeways are inspected once every 3-6 months, once every 6-12 months, and once every 5 years based on the importance of the assets. The field inspections are generally implemented through visual examination by engineers who have experience. Necessary timing and methods for rehabilitation are determined based on the engineers' knowledge and experiences. Engineers are considered to have enough knowledge and experience with on-the-job training to determine them without an accurate deterioration forecast.

2. Murray Irrigation Limited

Murray Irrigation Limited is Australia's largest private irrigation company, formed in 1995 as an unlisted public company[7]. The company is located along the Murray River in southern NSW, and the company's shareholders are the irrigator-customers who own 2,405 farms with an area of 748,000 ha. The company supplies them with water. Murray Irrigation Limited is responsible for maintaining the structural integrity of its irrigation and drainage systems. This includes 2,954 km of supply channel and 1,425 km of drainage canals, and more than 20,000 structures such as road bridges, channel regulators and water supply outlets, with a replacement value of more than $500 million. Murray Irrigation Limited delivers up to 12.4 billion m^3 of water a day for irrigation to 2,405 farms during the irrigation season from August to May through 1,798 channel regulators and more than 5,000 water supply outlets. Food and livestock are the focus of regional production including rice, wheat, and other cereals, canola, maize, tomatoes, potatoes, onions, fruit, milk, prime lambs, and cattle.

Murray Irrigation Limited has been receiving government grants of $7-8 million annually for asset management since privatization in 1995 and will receive grants for a period of 15 years until 2010. Murray Irrigation Limited has accumulated $35 million and will increase it up to $50 million in 2010 for asset management without the

government grants. In addition, Murray Irrigation Limited expects interest earnings of $4 million and water delivery profits of $2.5 million annually.

The average lifespan of capital assets is 100 years, based on engineering evaluations undertaken in 2002. Major assets worth more than $100,000 are constructed, refurbished and maintained to provide a lifespan of 120 years. Assets worth less than $100,000 are constructed, refurbished and maintained to provide a lifespan of 80 years. Minor assets have a lifespan of 20 to 40 years.

All irrigation channels are earthen canals (Fig. 3). They are expected to have unlimited lifespan with removal of sedimentation soil once every 10 years. The company's engineers consider that the earthen canals would have unlimited lifespan with appropriate inspection and removal of sedimentation soil. These appropriate inspections and removals of sedimentation soil are a part of asset management. The main assets requiring rehabilitation are farm road bridges over irrigation canals. The bridges deteriorate with the transit of heavy machineries and require appropriate maintenance and rehabilitation.

All assets are inspected mainly with visual examination once every 5 years, and the priority of rehabilitation is determined based on the engineers' judgments.

3. Murraumbidgee Irrigation Limited

Murranbidgee Irrigation Limited was formed in 1999 as an unlisted company[6]. The company is located along the Murrambidgee River in southern NSW, and its shareholders are the irrigator-customers who own about 2,050 farms. The company supplies them with water. Murranbidgee Irrigation Limited is responsible for maintaining the structural integrity of its irrigation and drainage systems. This includes about 2,500 km of supply channels and about 2,400 km of drainage canals, and other structures, with a replacement value of about $470 million. Murranbidgee Irrigation Limited delivers water for irrigation to about 2,050 farms with an irrigated area of 120,000 ha during the irrigation spell or periods. The main crops are wine grapes, rice, cereals, oil seeds, pastures, citrus, nuts, and olives, as well as chickens for meat production.

Murranbidgee Irrigation Limited has been receiving government grants of $7-8 million annually for asset management since privatization and will receive grants for a period of 15 years. Murranbidgee Irrigation Limited has not been accumulating necessary funds for asset management without the government grants after the 15 years while Murray Irrigation Limited has been accumulating necessary funds. The reason is as follows. Murranbidgee Irrigation Limited considers that all assets would have an unlimited lifespan with appropriate rehabilitation and reconstruction with the government grants during the 15 years after privatization, and that only $4 million would be necessary for asset management annually after the 15 years. They consider that only minimum inspection and rehabilitation would be required for the asset management after the completion of appropriate rehabilitation and reconstruction during the 15 years after privatization, including replacement of concrete canals with pipelines. They consider that the $4 million would be necessary for minimum inspection and rehabilitation.

About 90% of the 2,500 km of irrigation channels is earthen canal, and about 10% is concrete canal. The earthen canals are considered to have an unlimited lifespan with removal of sedimentation soil. The company's engineers consider that the earthen canal would not be destroyed with heavy rains as the precipitation is very limited in the region. However, minimum inspection and rehabilitation would be required as a part of asset management. Concrete canals (Fig. 4) have severely deteriorated as more than 60 years have passed since their construction. Murranbidgee Irrigation

Fig. 3. Earthen canal operated by Murray Irrigation Limited
Photographed by the author in March 2008.

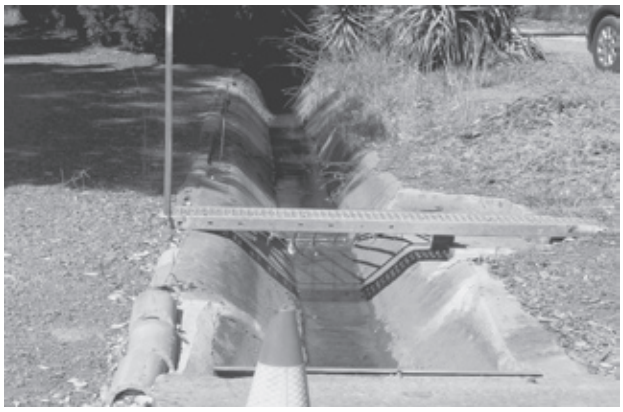

Fig. 4. Concrete canal operated by Murraumbidgee Irrigation Limited
Photographed by the author in March 2008.

Limited compared the LCCs of refurbishment as concrete canals and replacement with closed pipelines, and considered the replacement with closed pipelines as being costless and efficient. The lifespan of the closed pipelines is expected to be 60 years. A discount rate of 6% and calculation period of 100 years are used for LCC calculations. The calculated LCC's net present value of replacement with closed pipelines is less than that of refurbishment as concrete canals by using the discount rate and calculation years including replacement or refurbishment costs and future operation and maintenance costs. Therefore, Murranbidgee Irrigation Limited has decided to replace the concrete canals with closed pipelines to reduce LCC. A deterioration forecast of assets is not implemented for the LCC calculation, and the lifespan of the asset after the replacement is estimated based on the engineers' evaluation.

All assets are inspected mainly with visual examination once every 5 years, and the priority of rehabilitation is determined based on the engineers' judgments.

Discussion

1. Viewpoint of business management

Asset management of infrastructure has been generally considered as a systematic process of maintaining, upgrading and operating physical assets cost-effectively, by combining engineering principles with sound business practices and economic theory[9]. It provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.

One of the main characteristics of asset management in Australia is to consider farmers as customers and to maximize the customers' satisfaction. The corporatized or privatized organizations responsible for asset management, separated from NSW State Government, intend to reduce the necessary costs for asset management in order to prevent the increase in the water prices. IPART, which determines the price of water sold by State Water to its customers, requires State Water to reduce the costs for asset management in order to prevent an increase in customers' financial burden. Murray Irrigation Limited and Murranbidgee Irrigation Limited are non-profit private companies, and intend to minimize the necessary costs by reducing staff number and introducing a four day working week for staff. Murray Irrigation Limited also has been accumulating necessary funds for asset management after the 15 years of government grants.

The improvement in customers' satisfaction, cost reduction, and long-term financial sustainability can be considered as the viewpoint of business management required for asset management. However, in Japan such viewpoints of business management have not been fully considered. Customer satisfaction has not been fully taken into account by the government and land improvement districts. Also cost reduction and long-term financial sustainability have not been fully taken into account. These viewpoints of business management should be fully taken into account for asset management of irrigation infrastructure.

2. Discount rate

State Water uses WACCs for the discount rate which is used for calculating the net present value of the future cash flow for asset management. The discount rate is as high as about 10% reflecting the current economic prosperity in Australia while Murranbidgee Irrigation Limited uses 6% as the discount rate. However, it can be considered as a higher discount rate for the social cost benefit analysis. A lower social discount rate should be used for calculating the net present value of the future cash flow for asset management as State Water provides public services to the customers and it is a non-profit corporation. In Japan, 4% is used for the discount rate. Figure 5 shows the net present value of $1 with different discount rates and calculation periods. When the calculation period is 20 years, the net present value with 4% is about three times as much as the one with 10%. This means that the net present value becomes lower as the discount rate is higher. The size of the discount rate affects the net present value. Therefore, the percentage of the discount rate should be determined cautiously.

3. Lifespan of assets

The lifespan of the assets are evaluated based on engineers' knowledge and experiences. However, a method to more accurately forecast the actual lifespan of the assets including those after rehabilitation and replacement should be established in order to implement more effective and

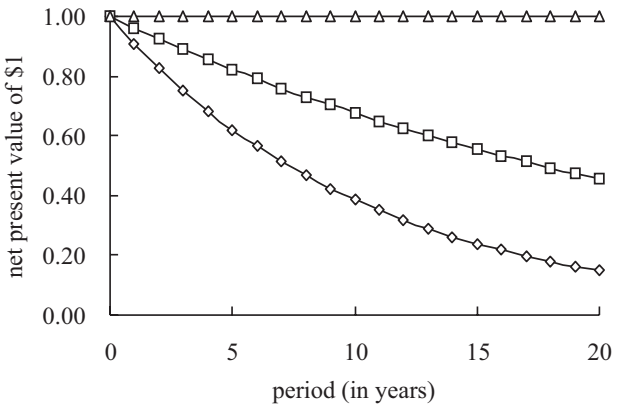

Fig. 5. Net present value with different discount rates

discount rate —◇— 10%, —□— 4%, —△— 0%

efficient asset management. The lifespan of assets would affect the calculation period of the future cash flow. Ideally the actual lifespan of assets should be used for the calculation period. In Japan, 40 years is used for the calculation period of reinforced concrete canals, and this would be different to the actual lifespan of the canals. Therefore, more accurate forecasts of actual lifespan of the assets should be required.

4. Deterioration forecast

The timing and methods of rehabilitation and replacement of assets are determined based on engineers' judgments taking into account the results of asset inspections, and a deterioration forecast is not implemented. However, accurate deterioration forecast methods are necessary to determine when and how assets should be rehabilitated and replaced with the lowest LCC in an efficient manner. As the deterioration forecast is the main research issue of asset management of road bridges in Japan, accurate deterioration forecast methods should be developed and used also for asset management of irrigation infrastructure.

Conclusion

This study reviewed various issues of irrigation infrastructure asset management in Australia. It has both advantages and disadvantages for appropriate implementation of asset management. These issues should be taken into account in implementing efficient asset management of irrigation infrastructure in developed countries such as Japan and developing countries.

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