

Research and analysis of correlation among cost efficient variables constituting the irrigation service price in Vietnam

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● **Abstract:** TSince Law on Hydraulic Work being effected, the orientation of irrigation and drainage service management of Vietnam are shifted from fee to pricing mechanisms in which the water users have to pay water tariff for service providers. Its main target is to enhance responsibilities and attention of service providers and users in improving of irrigation water provision and use efficiency. Besides assessing the irrigation and drainage performance by technical aspects, irrigation cost effectiveness per a service unit are also paid attention. With objectives of suitable use and effective distribution of funds among cost factors, the research initially assesses and identifies the rate of cost distribution and correlation between cost factors constituting price of irrigation service provided to users in Vietnam. The research results reported correlation between cost rates per an area unit or a cubic meter of each factor at significant levels upper 95% ($P>0.05$) and 99% ($P>0.01$) such as variables of labor wage (x2), regular repairs (x7), materials (x6) have tight correlation with the total cost (x1) at over 70%; between pair correlation between variables of labor wage (x2) and management cost (x8), other operating costs (x4), electricity (x5) are tight at over 85%; and variable of regular repairs (x7) are not correlation with other operating costs ((x4), electricity (x5), management costs (x8) and other costs (x9). Thus, the cost management policies assessment for irrigation management enterprises are recommendation

● **Key words:** irrigation service, fee, price, cost and irrigation efficiency



1. Introduction.

The purpose of this research is to review and assess the cost items in operating and maintaining the irrigation and drainage schemes to delivery water to various users including the cost data and correlation among the cost variables constituting irrigation service price. To demonstrate these objectives, the data on O&M costs of 41 provinces in 7 social economic regions of Vietnam are used. It is concerned that after the new law on hydraulic works being effected, the law's orientation is that irrigation and drainage service management is shifted from fee to pricing mechanisms and the service users have to pay costs of water service to providers. It is reason for enhancing responsibilities and attention of service providers in using efficiently financial resources towards saving cost, optimizing benefit and the water users will have more actions for saving water... Assessing the irrigation and drainage performance in new context is not only considered on basis of effectiveness of technical criteria but also on cost efficiency. Thus, with objectives of suitable use and effective allocation of budget among a number of cost items, the research initially assesses and identifies cost utilization efficiency by items of operating costs, maintenance, administrative costs and other reasonable costs; those distributions in the total cost and pair correlation between cost variables constituting irrigation service price in Vietnam irrigation sector.

2. Sustainably financing irrigation and drainage in Vietnam and its efficiency

In traditional concern, assessing the irrigation and drainage scheme's efficiency always based on the technical criteria such as water volume delivered (water loss rate, water volume used in a cultivated areas or crops irrigated areas in a systems or a years, environmental protection, on-farm water irrigation, multi water users provided... (Dinh Vu Thanh, et. al., 2007). When water services are priced, delivery of water services to users or farmer fields are also considered by satisfaction levels of both providers and receivers. It is mainly based on the economic or cost efficiency in water

use. It means that any its cost factor is valued on basis of irrigation service used by volume or areas (Mike Bryant, et. Al, 2003). The efficiency of schemes will also be measured by a set of socio-economic and technical indicators. The cost use and revenue efficiency are also considered as a key decision for implementing the agreement of irrigation service provision especially public irrigation services which are subsidized (Doan The Loi, et. al, 2018).

The costs of water services are suggested as full costs in which make sustainable water supply (Rogers et al. 1997). To delivery of irrigation water to users, the costs are identified under different expenditure types including O&M of irrigation schemes and its capital costs paid by irrigation entities. And there are some other costs such as opportunity costs and economic and environmental externalities assessed as the full economic cost, beyond the scope of this study because in the Vietnamese context at least, these types of costs are not accounted as common view of the irrigation sector (Rogers et al. 1997; Robert C. Johansson et. al. 2001).

Shifting to commercial agricultural production, irrigation water will be one of indispensable input factors and be requested with higher service quality such as more accuracy, flexibility and reliability, and then its finance also will be included full costs of irrigation service provision. These will be the challenges and opportunities for Vietnam irrigation sector because most of irrigation systems (about 904 systems) was constructed in 30-40 years ago target to paddy fields but absence of flow measurement and control devices, extensive field to field irrigation (Annual report of MARD, 2018). Moreover, the O&M of these systems are mainly implemented by irrigation stateowned enterprises (popularly called IMCs) by which their revenues depend on irrigation service fee subsidized by government. Although the subsidy sustained revenues for IMCs, it has weakened IMCs' responsibility with their clients such as poor irrigation service provision... and It also improves famers' welfare but reduced water-saving awareness in cropping-business. The subsidy also eliminates market-based features of irrigation

products, services. Movement from irrigation service fee subsidized to water pricing mechanism is imperative and specified in new Laws (Law on Hydraulic Work, 2017).

Before 2008, the irrigation service fee was directly paid by water users but the IMCs did not collect enough irrigation fee from them to cover their O&M costs resulting the irrigation service was gradually poorly provided and schemes were degraded. In 2008, understanding the revenue of IMC from the irrigation fee collected is too small comparing to payment of government for other economic sectors and status of poor rural farmers, the government decided to pay this fee instead of farmers by subsidizing directly to IMCs. This subsidy only covers the O&M cost for operating and maintaining headworks, primary and secondary channels and was understood as the partial cost recovery. Depreciation cost are also paid by government through extracting from process of fixed assets' capital cost saving. For the exceeding costs, IMCs had to continue collecting from the users or receiving from local government' supports. And O&M costs of on-farm irrigation schemes was paid by the self-farmers. In practically, all O&M costs of IMCs were covered by annual fixed subsidy of government without any revenue form fee collected.

As regulated in new law, water services in Vietnam are classified into two groups of public services providing irrigation services for small-medium individual farming; and other services providing water for the other social economic purposes. And regulating that water charges should cover full costs for O&M of schemes and ensure sustainable business of irrigation entities. However, it is not primarily raised without permission of local government and is in a pricing-frame regulated by Ministry of Finance. Currently government has just supported a part of water charges to the IMCs for their irrigation public services provision. Although understanding the enhancement of cost recovery was correlated with the standards achieved in operating and maintaining irrigation schemes and if they are inadequately maintained irrigation, facilities will be deteriorated rapidly (Baum, W. C.; Tolbert, S. M.. 1987). But, practically, subsidy of Vietnam

government could not cover all the O&M cost categories and allocation to the items seem to be inequality among cost factors resulting cost utilization efficiency reduced and schemes deteriorated. The irrigation financial managers meet difficulties in administrate the budget among the cost items to get the sustainability of the business.

3. Characteristics of costs in irrigation service provision and study methods

As regulated in new policies, the price of irrigation services is classified by 5 main cost groups including operating costs, maintenance, depreciation, administrative and other costs. They are the financial and economic costs ensuring a sustainable provision of irrigation water service (Rogers et al. 1997). This study is concerned with the identification of the financial costs involved in the provision of irrigation and drainage services. However, the depreciation and renewal costs did not be adequately identified in the financial sheets of IMCs and externalities, opportunity cost of capital are not also accounted for. Reliable financial data were obtained from provincial state owned irrigation agencies of 41 provinces from 2014-2016. They were selected through a purposive sampling process, with 7 socio-economical regions in whole country. This geographical representation was considered important given variability in water resources, irrigation management and socio-economic characteristics. For example, in the northern mountainous areas, irrigation schemes are closed and small scale systems; in the Red River Delta, the schemes are large scale pumping; in the Mekong region, the schemes are opening systems and availability of water resources from river systems; in the highland, central and south east regions, the schemes exploit water from reservoirs by pumping or gravity irrigation regimes. The water users in Mekong and highland areas are quite familiar with the water market while in other regions, the farmers still keep their mind of dependence on subsidy sources of government.

Data collection instruments like balance sheets were designed as templates to gather a comprehensive set of costs classified into 5

groups of cost categories such as the operating, maintenance, depreciation, administrative, other reasonable costs (table 1). The data collection templates was piloted in some provinces and then refined prior to use for collecting cost data at other provinces. As the focus was on the costs incurred by the service providers such as provincial irrigation companies, boards and centers

Table 1. Summary of measures of financial viability

Cost categories (*)	Description
Total O&M costs	Total of all expenses for O&M activities
(1) Operating costs	
- Wages and salaries	Payment for labor, allowances and payment relating to salaries of labors such as social and health insurance; union fee... what are paid by the irrigation enterprises
- Relative cost for labor	Payment for staff training fee; scientific research; adaptation of new technologies; Labor safety and protection; Unemployed pension and insurance.
- Other operating costs	Flooding monitoring and structural protection; bulk water fee; cost of water fee collection from areas not being subsidized; contingency; others.
- Power electricity	Payment for electric power used for running the pumping systems.
- Materials costs	Fuel, oil, cleaning materials, aiming...
(2) Maintenance cost	
- Maintenance cost	Regular maintenance and repairs; some medium repairs
(3) Depreciation cost	annual depreciation was calculated based on a straight-line method applied to capital expenditure, but it is difficult to estimate with irrigation schemes in Vietnam
(4) Management cost	
- Management costs	Payment for materials supporting administrative management, workshop and meeting participation, external expenditures; stationary, other payment by cash, fee, tax...
(5) Reasonable costs	
- Other costs	Financial payment; rewarding and welfare funds; depreciation of fixed assets, reservoir monitoring and evaluation; communication, protection and others; technical economic cost norm establishment...

(*): Cost categories are based on regulations in degree 96/2018/ND-CP on detailed regulating on irrigation service price and cost supportiveness for public irrigation service.

4. Data analysis and discussion

Financial data was drawn from various sources and each data sheet, individual cost items were aggregated and assessed for each category as defined and regulated in the Degree 96/2018/ND-CP and in concepts of financial costs by Rogers et al. (1997) and J Robert C. Johansson et al. (2001). All costs were converted to US dollars in 2016 by applying deflator factors and a period

average exchange rate of USD 1 equal to VND 21,935 (World Bank 2018a, 2018b). The annual depreciation was determined based on a straight-line method applied to capital expenditure but this item was excluded in the cost categories in managing finance in irrigation sector in Vietnam. The performance measures evaluated in this study were cost efficiency of the schemes referred from Malano and Burton (2001) (table 2).

Table 1. Summary of measures of financial viability

Cost categories (*)	Individual costs as a percentage of total expenses (%)	Performance measures (USD/ha or m ³)
1) Operating costs	Operating costs/Average of total O&M costs	Operating costs/total of areas or cubic meter converted to rice irrigation
- Wages and salaries		
- Relative cost for labor		
- Other operating costs		
- Power electricity		
- Materials costs		
2) Maintenance cost	Maintenance cost/Average of total O&M costs	Maintenance cost/ total of areas or cubic meter converted to rice irrigation
- Maintenance cost		
3) Depreciation cost	Depreciation cost/Average of total O&M costs	Depreciation cost/ total of areas or cubic meter converted to rice irrigation
4) Management cost	Management costs/ Average of total O&M costs	Management costs/ total of areas or cubic meter converted to rice irrigation
- Management costs		
5) reasonable costs	Management costs/ total of areas or cubic meter converted to rice irrigation	Other costs/ total of areas or cubic meter converted to rice irrigation
- Other costs		

Total cost calculated from the obtained data set averaged 46,13 USD per hectare of irrigation and drainage areas which are converted by water volume consumption of other crops to rice cultivation per season with 2.13 standard deviation. The results of average tested at significant level of 95% ($P > 0,05$) reveal that there are 95% of samples having average total O&M cost ranged from USD41.9 to USD50.35. The operating cost is USD27.21 per rice hectare in which the highest level belongs to the wage and salaries and maintenance costs categories. The average total cost per volume is USD6.8 per 1000 cubic meter with standard deviation USD0.4.

And at the significant 95% level, there are about 95% of samples averaged from USD 6.0-7.5. Assessing financial data among years from 2014-2016, total of management costs and other cost gradually reduced. In contrast, other cost categories were increased with a small rate being equal to the increasing level of other sectors. The reason was that amount subsidy of government hasn't changed since 2012 which were regulated in Degree 67/2012/ND-CP on regulating the subsidy levels for irrigation public services and revenues from providing other services products is not implemented.

No	Variables	Mean	Std. Err.	[95% Conf.	Interval]
I	Average O&M cost per area (USD/ha)				
1	Total O&M costs	46,13	2,13	41,90	50,35
2	Wages and salaries	21,12	1,26	18,64	23,61
3	Relative cost for labor	0,41	0,06	0,28	0,53
4	Other operating costs	1,46	0,26	0,95	1,97
5	Power electricity	3,74	0,46	2,82	4,66
6	Materials costs	0,47	0,05	0,38	0,57
7	Maintenance costs	15,99	0,98	14,06	17,92
8	Management/Administrative costs	2,95	0,21	2,53	3,37
9	Other costs	1,16	0,20	0,77	1,55

No	Variables	Mean	Std. Err.	[95% Conf.	Interval]
II	Average O&M cost per volume (USD/1000 cubic meter)				
1	Total O&M costs	6,8	0,4	6,0	7,5
2	Wages and salaries	3,2	0,2	2,7	3,6
3	Relative cost for labor	0,1	0,0	0,0	0,1
4	Other operating costs	0,2	0,0	0,1	0,3
5	Power electricity	0,5	0,1	0,4	0,6
6	Materials costs	0,1	0,0	0,1	0,1
7	Maintenance costs	2,3	0,2	2,0	2,7
8	Management/Administrative costs	0,5	0,0	0,4	0,6
9	Other costs	0,2	0,0	0,1	0,2

The figure 1 shows that costs of wage and salaries and maintenance items constituted the major O&M cost categories, amounting to 46% and 34% of the average costs in respectively, followed by administrative costs (6.4%). The wage and salaries costs increased yearly due to a number of labor was not reduced while governmental policies regulated the yearly increase of salary indexes. The payment for the electricity depended on status of irrigation systems of each province, if there were many pumping irrigation systems, the rate of electricity costs occupied at the high level. Some provinces in center areas where most of irrigation is electricity pumping stations, costs for electricity use averaged at 10-20% in total such as in Thanh Hoa, Nghe An and Da Nang provinces. Average of other cost percentage is about 2,52%,

but in practically some provinces pay for these costs at 15-24% of the total (Doan The Loi, et al. 2019), especially at level of 43-45% with the Quang Ngai province

As mentioned above, almost of the irrigation infrastructures were invested and constructed by government funds and their initial capitals were very huge; therefore their depreciation cost seem not estimable and were not included in the full cost of O&M. Practically, government will be responsibility in this investment. For the specific irrigation schemes for target of providing irrigation services to commercials or high value agricultural production, their depreciation cost will be include in the total cost which also be charged to those users. Anyway, their full cost will be significantly increased.

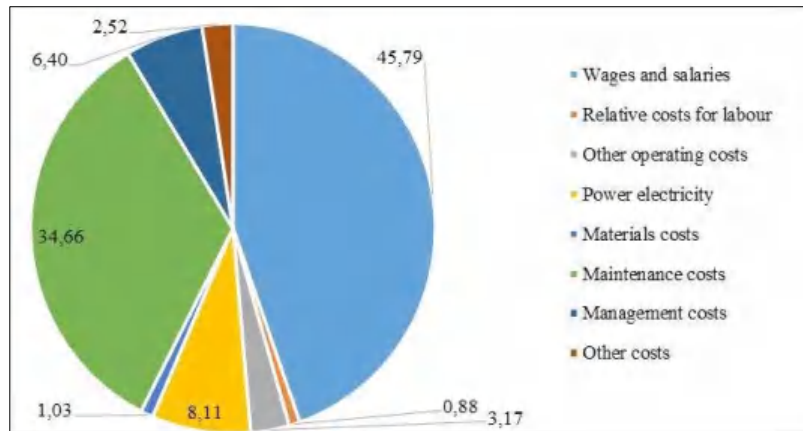


Figure 1. Portion of O&M cost by variables constituting irrigation service price from 2014-2016 (%)

In practice, pumping schemes spend much more labor and materials than gravity systems if having more possible condition which will reduce significantly the costs of the provincial irrigation sector. There are relative high staffing levels, and difficulties to adjust the workforce as legal regulations, because high percentage of them was low trained and educated as practical irrigation requests. Therefore, to improve labor productivities and reduce the labor costs and their relative costs should be well planned and become more important for aims of modernization (World Bank, 2013).

From 5 groups of cost categories, there were 9 cost variables grouped in which the total cost is a dependent variable and others 8 independent variables being from 5 cost categories. The operating cost categories were also classified into 5 variables on basis of their practical effects and rate in the total cost. The pair correlation analysis model was used to test and analyze the data set and identify the regression between variables as pair cost variables correlation. The STATA program was used as instrument for processing data and criteria calculation.

Correlation assessment of cost variables at significant 99% ($P>0,01$) reported that almost of cost variables of Relative cost for labor (X3) and Other costs (X9) had a bit light correlation with the total cost variable at levels of 27% and 37.9%, in respectively. The strongest correlation was 84,7% with Wage and salaries (X2) and with other variables were at levels of 60-70% correlation.

With pair correlation between independent variables were different, the pair variables between Maintenance costs (X7) and Relative costs for labor (X3), Other operating costs (X4), Power electricity(X5), Management costs (X8) and Other costs (X9) are not correlations at significant level of 95% ($P>0.05$). The pair comparison between Other costs (X9) and X3, X6 and X7 were also not correlation at significant 95%, even correlation co-efficient was minus but this variable was not correlation.

The Wage and salaries variable (X2) strongly correlated with all other variables at ignificant 99% in which with X6 and X7 variables being light correlation at levels of 49 and 29%, in respectively. The Relative cost for labor variable (X3) was light correlation with variables of X4, X5, X6 and X8 lower 50%. Other operating costs variable (X4) strongly correlated with X5 and X9, and lightly with X6.

The strong pair correlation among wage and salaries and others variables was suitable with Vietnam's irrigation condition when almost of them are old age from 30-40 years and high demand of maintenance and repairs. They also seem not have the control and monitoring devices. Operating these systems need much more normal labor forces and also high amount of materials for maintenance and operation comparing with other few new upgrading systems. The increases of labors costs in O&M cost structure will result to more utilization of materials and fuels as well as other relative expenditures.



Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1: Total O&M costs	1.00								
X2: Wages and salaries	0.847**	1.00							
P>t	0.0000								
X3: Relative cost of labor	0.277**	0.352**	1.00						
P>t	0.0019	0.0001							
X4: Other operating costs	0.652**	0.853**	0.402**	1.00					
P>t	0.0000	0.0000	0.0000						
X5: Power electricity	0.661**	0.870**	0.405**	0.793**	1.00				
P>t	0.0000	0.0000	0.0000	0.0000					
X6: Materials costs	0.721**	0.492**	0.293**	0.289*	0.290**	1.00			
P>t	0.0000	0.0000	0.0010	0.0012	0.0011				
X7: Maintenance costs	0.755**	0.299**	0.027	0.089	0.079	0.700**	1.00		
P>t	0.0000	0.0008	0.7643	0.3231	0.3799	0.0000			
X8: Management costs	0.679**	0.907**	0.177*	0.868**	0.788**	0.285**	0.098	1.00	
P>t	0.0000	0.0000	0.0500	0.0000	0.0000	0.0014	0.2765		
X9: Other costs	0.379**	0.566**	0.110	0.595**	0.536**	0.110	-0.024	0.586**	1.00
P>t	0.0000	0.0000	0.2257	0.0000	0.0000	0.2232	0.7900	0.0000	

** Correlation is significant at the 0,01 level, * Correlation is significant at the 0,05 level.

5. Conclusion and implication

The cost data of O&M management of irrigation sectors in 41 provinces included the financial costs without the capital charges. There are also different distributions among cost items and categories of fixed subsidy sources and even they were not formulated and recorded well as the financial balance sheets. The financial cost of O&M management for operating irrigation schemes have been calculated and considered at average of 46,13 USD per hectare of irrigation and drainage areas of rice cultivation per season with 2.13 standard deviation and average of USD6.8 total cost per 1000 cubic meter with standard deviation USD0.4 in which labor cost and maintenance cost occupied at the highest levels (46% and 35%, in respectively). In term of consideration of costs categories, distribution rate and drivers of those costs, the salaries and wages and maintenance costs are main drivers in O&M cost components which highly impacted on the other cost items and cost utilization efficiency in irrigation public services provision. Practically, there were also the inadequate allocation among

the cost items when used subsidy sources for operating the irrigation schemes. Therefore, they are clear implications for policies and practice of O&M cost management of irrigation schemes in irrigation sector of Vietnam. The results also become the valuable reference points for central and local government making relevant policies decision. Then, the government in Vietnam need to invest in evidence-based process to recognize the real costs of irrigation schemes over the long-term and use these to inform national frames of technical economic norms and appropriate tariff structures and frame, and subsidies for public irrigation products and services. The economics of opportunity costs for water and environmental externalities should be considered in new context of price mechanism application. Efficient concepts of the O&M management of the schemes is not only on basis of area, water volume but also productivity of labor and costs items.

The results also shown the pair correlation among variables of labor wage and salaries (x2), maintenance (x7), materials (x6) have significant correlation with the total cost (x1) at over 70%;

between pair correlation between variables of labor wage and salaries (x2) and management cost (x8), other operating costs (x4), electricity (x5) are tight at over 85%; and variables of regular repairs (x7) were not correlation with other operating costs (x4), electricity (x5), management costs (x8) and other costs (x9). All of them correlated at significant level 99% and 95% ($P > 0.01$ and $P > 0.05$). They will be evidence for next steps of analyzing cost data set by model of Panel Data Analysis Fixed and

Random Effects as assumption of identification of effective levels of dependent and independent variables to cost utilization efficiency and irrigation performance over time and all irrigation sectors. Then, the new research results will provide the evidence-base for designing the scenarios of impacts on cost items constituting price of public irrigation products and services and given out the solution policies on the water tariff supportiveness by government.

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