Toward modernization of irrigation from concept to implementations: Indonesia case

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Abstract. In the last decades before entering 21st century, many countries of the world have been facing critical issues of less in food production, lack energy availability and weak water resources management as well. Besides of these issues another phenomenon dealing with climate change also is coming up and treating peoples in some respects. In the developing country such as Indonesia environmental load in term of increasing population rate occur tremendously. More peoples mean more resources have to be provided. However, some recourse is scares and others are not available every time. Better water resources management even this aspect was considered as critical one, but it was could be used as a tool to solve the problems properly. Increasing water users in the river basin would also create competition among of them. Recently about 80 % of water use in the world goes to irrigation purposes and most of them are managed inefficient and less effective way. Changing of government policy and change of ecology may made irrigation water management getting worst. Irrigation management could not implement by using conventional method. A new approach to make irrigation management running better must be setting up. The Ministry of public works and Housing to represent Government of Republic of Indonesia launched irrigation modernization of Indonesia program in year of 2011. This paper aims to present concept and implementation progress of the Program.

1. Introduction
In the last decades before entering 21st century, many countries of the world have been facing critical issues of lack of food production, energy and water resources as well. Besides of these issues another phenomenon dealing with climate change also is coming up and treating peoples in some respects. Indonesia also faces environmental load in term of increasing population rate occur tremendously. Increasing population means increasing resources should be provided. However, some resources has already scared and not the available every time.

In the monsoon tropical country like Indonesia rain is not distributed evenly in both in time and space. So, water naturally also available seasonally. During rainy season water may available everywhere some time cause of flood, however in other side during dry season water is very limited
cause a lot of problems to people in many places. These problems may need to be solved in comprehensively and appropriate way. Increasing population could also make decreasing of water quality and disturb the quality of people life as well.

Better water resources management is considered as critical issue of the country. Increasing water users in the river basin would create competition among of them. Recently about 80% of water use in the world goes to irrigation purposes and most of them are managed inefficient and less effective way. According to World Food Summit, only about 45% of the irrigated water is actually used by crops. Most of part irrigation water loss in distribution channels, ineffective irrigation management, and poor irrigation infrastructure [1].

New policy in irrigation management must be immediately administered. The Ministry of public works and Housing to represent Government of Republic of Indonesia launched irrigation modernization of Indonesia program in year of 2012 to be implemented in the country. This paper aims to present concept and implementation progress of the Program under this policy.

2. Rationale

Most of irrigation systems of Indonesia were rehabilitated during in the early of 1970’s decade under president Suharto era or even some of them were built previously. Environment (either both strategic and ecology) of the most of irrigation system has changed significantly may make irrigation water management is getting worst. As result implementation of Irrigation management including rehabilitation works of irrigation infrastructure could not implement conventionally it need a modernization of irrigation process.

3. Premise

Globally, modernization of irrigation program was initially started in 1995 just after FAO workshop about modernization of irrigation held in Bangkok, Thailand. Following the workshop many countries including Indonesia set up their own program based on the country need. Even actually, Indonesia had already implemented modernization of irrigation program sporadically. In the end of 1980’s decade the Sidorejo Irrigation system was developed by applying downstream control instead of upstream control that be implementing in the most irrigation system in Indonesia. Eventually this program was not properly worked due to three main reasons, i.e. (i) improperly infrastructure design, and (ii) improper institution set up, and (iii) social and economic aspects in term of misunderstanding to policy of both government official and farmer as well [3].

Implementation of Asset Management Plan (AMP) for irrigation operation and maintenances is another example unsuccess story of modernization of irrigation implementation in Indonesia. The AMP was introduced by Gadjah Mada University collaborated with Southampton University and Ministry of public works in 1995. Ministry of public works adopted this concept in 2012 under Asset Irrigation Management (PAI) program [3]. In development of Rentang Irrigation System and Sempor Dam a new computerized O&M irrigation system procedure was also introduced to be implemented in the system, nevertheless after a couple’s years these O&M procedures did not work properly and O&M implementation procedure back to the conventional ones [4].

Learning from previous modernization of irrigation program it is concluded that unsustainable implementation program of Modernization of Irrigation in the past was due to several reasons as follows: (i) no legal basis to support implementation program, it made bureaucracy staff as program implementer officially faced difficulties to propose implementation budged for running the program, (ii) improper infrastructure design with ignoring local knowledge and local physical characteristic, (iii) limited participation of farmers due to misunderstandings and knowledge gap between farmers and bureaucracy during program implementation, (iv) less communication and technology and occurrences gap between bureaucracy as program implementer and farmers as irrigation water user in the system, and (v) weak human capital and institution program implementer.

Considering to learning process of the last past experiences setting up the legal basis to implement next modernization of irrigation program was consider as most important and strategic step.
Unfortunately, after cancelation of Water Law no 7 year of 2004 recently Indonesia has no progressive water law could be used as basic law to formulate some concepts with new perception in water resources management and irrigation water management scope. The existing the Water Law no 11 year of 1974 was considered very weak to accommodate emerging some new phenomena in water resources management since this water law was issued during president Soeharto era with different governance system and different environment challenging as well.

Meanwhile waiting for setting up the new water law, the Ministry of Public Work and Housing issued some ministry decrees dealing with all aspects of water resources management including irrigation development and management [5]. One article of this Ministry Decree support to Implementation of modernization in the country.

Actually, this decree substantially has no different with previous Government Regulation no 20 year of 2016 about irrigation. Both regulations contain some important principles of irrigation management as follows: (i) applying joint irrigation management concept, with main system is under government responsibility and farmers to be responsible in terrier level, (ii) implementation authority of irrigation management based on area is still valid, Irrigation system with area more than 3000 ha is under Central Government, irrigation area between 1000 ha -3000 ha is under Provincial Government responsibility, and irrigation less than 1000 ha is under District Government authority, respectively, (iii) application participation approach in implementation Irrigation management, (v) Irrigation management is done based on five pillars of Irrigation, those were water availability, infrastructure, irrigation O&M, Institutions and human capital and these is called five pillars of irrigation. Relationship of these 5 pillars as a part of agriculture production system is shown in Figure 1.

![Figure 1. Five pillars of irrigation as a part of agriculture productions [6]](image-url)

Figure 1 explains that the performance of the irrigation system as consisting of five pillars is strongly affected by the system environment both strategically and ecologically. Infrastructure is importance factor, it can influence water availability if the institution and human capital O&M are not showing good performance respectively. Actually, relationships among subsystems of pillars are very complex as shown in Figure 2. A lot of efforts are needed to have better irrigation management performances. Some
of the are very hard to be implemented in Indonesia. For example, coordination among institutions really very difficult to have since budgeting system of ministry uses sectoral programs.

4. Definition
Following the 1995’ FAO workshop on modernization of irrigation in Bangkok, at least two definitions of modernization of irrigation given by FAO and ICID were available. FAO defined modernization of irrigation as combined strategy of institutional, managerial and technological change with the objective to change from a supply to service oriented mode of operation, while ICID defines modernization of irrigation as the process of improving an existing project to meet new project criteria. It includes changes to the existing facilities operational procedures, management, and institutional aspects.

Different with these two definitions Indonesia had their own definition as: process to proceed participatory irrigation system management in efficient and effective way in order to attain better level of service and support to food security of the country based on application better management of five pillars of irrigation, i.e. Better condition of water availability, properly designed and constructed of irrigation infrastructures, feasible and flexible irrigation management to accommodate changing on social and economic characteristic and technologies development, strong and well managed of both bureaucracy and famers institutions, the last but not least competence human capital in irrigation management [7].

5. Objective
The main objective of modernization of irrigation in Indonesia is to develop participatory modern irrigation system in efficient and effective way to attain better level of services to farmer in term of water flexibility, sufficiency, equity, reliability, resiliency and vulnerability, respectively.

6. Concept Development
Modernization of irrigation concept is developed with several assumptions these are: (i) limited local resources in term water, funding, and official staff, (ii) multi water users in river river course, (iii) accommodating crop diversification culture, (iv) applying five pillars of irrigation management, (v) should be implemented in the participatory approach, and (vi) implementing in stages.

From Figure 2 ones knows is very difficult to be implement in ideal ones, it need some adjustment and strong, modern and commanding institution which may able to accommodate new technology development for modernization purpose, so hopefully it may will able to proceed an efficient, effective, accurate, flexible management irrigation system in the modernization principles. Adjustments effort that be needed to move from conventional irrigation is depicted in Figure 3.
Increasing of water demand in the river basin with limited water resources emerged a big problems
in water allocation among users. Figure 1 depicts a real problems in river basin level and hopefully by
applying modernization of irrigation it may solve the problems or at least minimizing to some extent.
Prior to implementation of modernization of irrigation hopefully efficiency of irrigation system is about
45% and these will be increase by about 60% with some efforts of modernization of irrigation

Figure 3. Transition efforts from conventional irrigation system to modernization [7]

Figure 4. Modernization of irrigation and water allocation problems
In river course [8]

6.1. Scope of Modernization
Some text. Modernization of irrigation has scope as follows:
1. Water Resources Development Improvement
2. Irrigation Infrastructure Rehabilitation and Upgrading
3. Irrigation Scheme Management
4. Institutional Strengthening
5. Human Resources Empowerment

6.1.1. Pillar no 1 Water availability improvement. In irrigation modern water availability is developed based on three approaches, i.e. (i) institutional development is done with strengthening coordination and encourage dialog among institution and stakeholders, development participation approach to have better understanding among users and raising sense of belonging of all stakeholder, regulation setting up and advocacy about water right, and (ii) infrastructure development in both in stream and off stream, such as developing dams, ponds and other water storage structure in watershed level and long storage irrigation system.

6.1.2. Pillar no 2 Infrastructures development. All of infrastructure form headwork until end structure in the irrigation system are built completely in properly design and well-constructed. Farmers may participate in all process from beginning to the end construction process. Design process is done with respecting to local knowledge and local available resources.

6.1.3. Pillar no 3 Irrigation scheme management (O&M). As basic assumption irrigation modern was managed with new criteria i.e. demand approach, real time basis on planning, water allocation, total losses, and implementing good irrigation governance. Operation and maintenance of irrigation system should be done in efficient, effective, accurate, and simple operated. All efforts are very difficult to be done manually, so application of information and communication and computerized technology is encouraged to be applied

6.1.4. Pillar no 4. Institution development. In some recent conventional irrigation system, institution and human resources performance are considered as the weakest aspects of irrigation management. In modern irrigation institution both bureaucracy and farmers institutions must be strengthen, water user association should be empowered to be a self-help organization. It is proposed modern irrigation system is implemented by special irrigation management unit (SIMU) and lead by irrigation manager. The SIMU consist of three sub unit O&M, empowerment and knowledge management centre, and security of irrigation networks, respectively.

6.1.5. Pillar no 5 Human capital. In the conventional irrigation system peoples in water management system is considered as input of production process. In the irrigation modern this perception is no longer used. In the irrigation modern system human capital concept and knowledge management concept are proposed to be implemented, Hopefully by applying these concept irrigation staffs will get more dignity to their job.

6.2. Implementation of the Program
Program of modernization of irrigation is implemented in six steps and done in stages as follows:
(i) set up modernization of irrigation regulation,
(ii) preparation is done in two steps
   a. by developing tool to assess of readiness of irrigation scheme to proceed irrigation modern index (RPIMI). This index is used to measure readiness irrigation scheme to implement modernization of irrigation. The RPIMI is developed based on five pillars in simple way but accurate enough as assessment tool. Survey of RPIMI is done by applying rapid assessment,
   b. implementation of RPIMI in selected typology irrigation system as pilot irrigation scheme
(iii) implementation of RPIMI as public consultation,
(iv) public consultation,
(v) development of system planning and detail design, and
(vi) Completing program implementations.

7. Result

7.1. Regulation on Modernization of Irrigation
Based on Ministry of PWH decree no 15/2015 about development and irrigation management, the directorate general of Water Resources issued a Circular Letter about Technical Implementation Procedure of Modernization of Irrigation in the end of 2018 to all head of river management Unit. By this Circular Letter, Modernization of irrigation legally can be started to be implemented in the country.

7.2. Developing RPIMI
RPIMI is developed to measure all of five pillars actual performances of Irrigation Scheme to be modernized. Indicators, category and criteria used to measure those pillar performances is shown in Table 1 and Table 2.

| No | Indicator                | Allocated point | Category | Weighted point | Point |
|----|--------------------------|-----------------|----------|----------------|-------|
| 1  | Water availability       | 15              | Good     | > 80           | 6=3x5 |
|    |                          |                 | Fair     | 50 up to 80    |       |
|    |                          |                 | Poor     | < 50           |       |
| 2  | Irrigation Infrastructure| 30              | Good     | > 80           |       |
|    |                          |                 | Fair     | 50 up to 80    |       |
|    |                          |                 | Poor     | < 50           |       |
| 3  | System Management        | 20              | Good     | > 80           |       |
|    |                          |                 | Fair     | 50 up to 80    |       |
|    |                          |                 | Poor     | < 50           |       |
| 4  | Institution              | 20              | Good     | > 80           |       |
|    |                          |                 | Fair     | 50 up to 80    |       |
|    |                          |                 | Poor     | < 50           |       |
| 5  | Human Resources          | 15              | Good     | > 80           |       |
|    |                          |                 | Fair     | 50 up to 80    |       |
|    |                          |                 | Poor     | < 50           |       |
| Total |                        | 100            |          |                | Total point |

Table 2. Criteria for each category

| Indicator      | Category | Criteria                                                                 |
|----------------|----------|--------------------------------------------------------------------------|
| Water Availability | Good     | Water is available to achieve 200% of paddy and 50% of cash crops        |
|                 | Fair     | Water is available to achieve 120-150% of paddy and 20-40% of cash crops|
|                 | Poor     | Water is available to achieve 100-120% of paddy and 15-30% of cash crops|
|                      | Good                      | To be described in table 4 |
|----------------------|---------------------------|---------------------------|
| **Irrigation Infrastructure** | **Fair**                   | To be described in table 4 |
|                      | **Poor**                  | To be described in table 4 |
| **System Management** | **Good**                  | fulfil 10 criteria:       |
|                      |                           | a. Availability and consistency on OM manual |
|                      |                           | b. Application using OM form |
|                      |                           | c. Availability of supporting document |
|                      |                           | d. Availability and consistency on gate and de-silting basin operation |
|                      |                           | e. Sufficient and proper maintenance on irrigation scheme |
|                      |                           | f. Proper operation on drainage |
|                      |                           | g. Availability and consistency on water management at tertiary level |
|                      |                           | h. Sufficient and proper OM on tertiary gate |
|                      |                           | i. OM Need based budget adoption |
|                      |                           | j. Asset management has been implemented |
| **Institution**      | **Good**                  | Fulfil 5 up to 9 of the 10 above criteria |
|                      | **Poor**                  | fulfil less than 5 of the 10 criteria above |
|                      |                           | fulfil of 10 criteria:    |
|                      |                           | a. Water resources apex body has already established and to be activated |
|                      |                           | b. Irrigation commission has already established and to be activated |
|                      |                           | c. Irrigation commission has already performed their good function as coordinating body |
|                      |                           | d. Local government has special attention on irrigation development and management. |
|                      |                           | e. Local government has already performed their function as regulator |
|                      |                           | f. River Basin Organization/Local Implementation Unit has already performed their good function as developer or operator |
|                      |                           | g. Water user association (WUA) and its federation has already established and active’ |
Water user association and its federation has already performed their participation on irrigation development and management at main system as user.

Water user association has already performed their participation on irrigation development and management at tertiary system as user.

Create the unity of irrigation development and management

| Human Resources | Fair | Poor | Good |
|-----------------|------|------|------|
|                 | fulfil 5 up to 9 of the 10 above criteria | fulfil less than 5 of 10 criteria above | fulfil 10 criteria: |

- OM management and staff are sufficiency available;
- OM management and staff with governmental status are more than 50%.
- OM management and staff with functional position status are more than 20%;
- OM management and staff with obtaining competence certificate are more than 20%;
- OM management and staff with obtaining training certificate are more than 20%;
- 40% of WUA should have been trained
- 40% of farmer should be as landholder
- Farmers have performed their sense of belonging and participation, appreciate on irrigation, and good response on irrigation development and management.
- 60% of farmers are capable and willing to pay to WUA contributions;
- 20% of farmers have more 2 Ha of paddy field.

Survey of RPIMI is done using Rapid Appraisal Method with Likert Scale analysis. Criteria for illegibility for irrigation scheme to be modernized the scheme has 80 total score.

7.3. Survey of RPIMI
Survey RPIMI has been done in 16 schemes. Measurement result is shown in table 3.
Table 3. Result of RPIMI

| No | Irrigation scheme | area (ha) | Survey year | RPMI Total Score |
|----|-------------------|-----------|-------------|------------------|
| 1  | DI Wadaslintang   | 31.133    | 2014        | 77,6             |
| 2  | DI Bondoyudo     | 11.784    | 2014        | 81,5             |
| 3  | DI Batang Anai   |           |             | 63,2             |
| 4  | DI Rentang       | 87.840    | 2015        | 66,9             |
| 5  | DI Jatiluhur     | 240.000   | 2015        | 68               |
| 6  | DI Saddang       | 60.300    | 2015        | 68,7             |
| 7  | DI Colo          | 26.234    | 2016        | 69               |
| 8  | DI Mrican        | 31.272    | 2016        | 77,9             |
| 9  | DI Komering      | 62.536    | 2017        | 66               |
| 10 | DI Sekampung     | 55.373    | 2017        | 75               |
| 11 | DI Serayu        | 20.795,60 | 2017        | 85,8             |
| 12 | DI Cikeusik      | 6.899     | 2018        | 66,3             |
| 13 | DI Kedung Putri | 4.341     | 2018        | 68,5             |
| 14 | DI Pamukkulu     | 6.256     | 2018        | 67.86            |
| 15 | DI Talang        | 8.844     | 2018        | 67.3             |
| 16 | DI Jurang Batu   | 3.500     | 2018        | 62,4             |

Sources: MPWH 2014b, 2015, 2016a, 2017, 2018

Table 3 shows that only Bondoyudo and Serayu irrigation Scheme have total score more than 80 and are eligible and ready to be modernized. The others need some improvement mainly pillar Irrigation management (pillar 3), institution (pillar 4) and human resources (pillar 5).

7.4. **Infrastructure development**

System planning for complete implementation of modernization if irrigation has already done in Wadaslintang Irrigation scheme in 2016 [12] and other four irrigation schemes in Java have been doing presently.

7.5. **Irrigation management improvement**

Irrigation management improvement in term system information technology for modernization of irrigation named SIMASI ver.1 has been developed in Wadaslintang Irrigation System and presently is developed to SIMASI ver.2. The different between both of two version more on formula they used and program platform. If SIMASI Ver. 1 uses Delphi dan Firebird Database Server it will be developed on WEB program basis. Other differences between two of them are: (i) most formula of O&M used in SIMASI ver.1 based on assumptions and literature review while SIMASI ver. 2 uses uses real formula based on direct measurement in field is been doing by Ministry of PWH [13].

7.6. **Institution strengthening and Human resources empowerment**

Study on modernization of irrigation management unit (MIMU) development had been in Colo and Lodoyo Irrigation Schemes [10,11]. Empowerment Unit of Tata Guna Air, PGA,) has been ordered to be developed in all River Basin Management Unit. Beside as empowerment unit, the TGA as also designed as KMC unit [14].

8. **Concluding Remark**

The implementation of irrigation moderation in Indonesia has gone a long way, from 2012 when it started up to recently and still to be developed. During development process the government faced a lot
of problems, The most difficulties is aligning perceptions among actors including farmers and irrigation staff both at the level of policy makers and field officers.

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