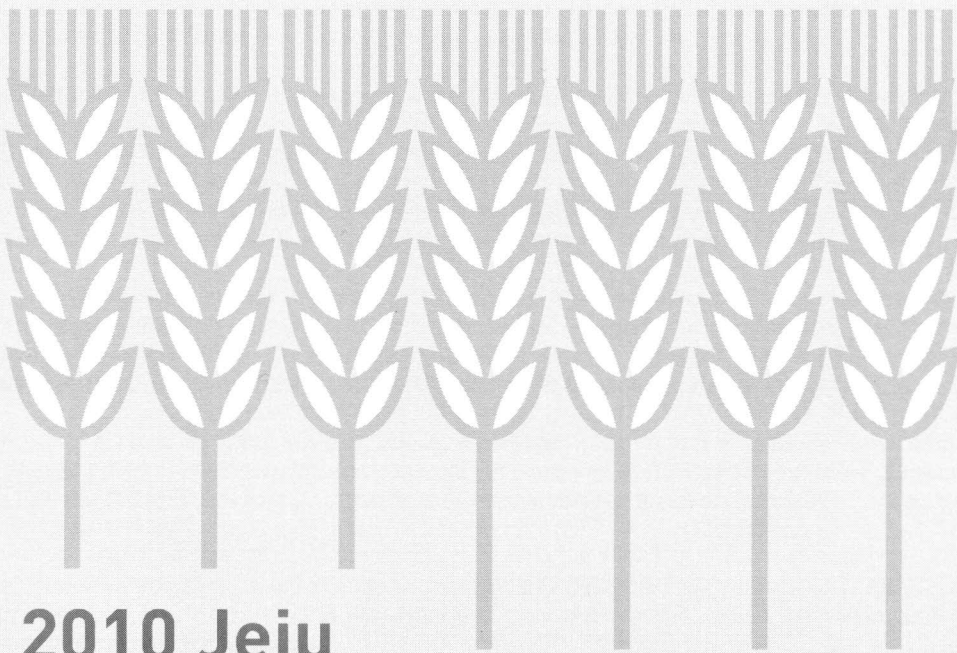




2010 Jeju

INWEPF - PAWEES

Joint Symposium & Steering Meeting



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October 27~29, 2010 ICC Jeju

Contents of table

Opening ceremony

1. Opening remarks: Chairman of INWEPF Korean Committee, Mr. Hwang-Keun Chung
2. Congratulatory remarks: President of PAWEES, Dr. Tsuyoshi Miyazaki
3. Congratulatory remarks: Director General RRI, Mr. HaeSung Park,
4. Congratulatory remarks: President of KSAE, Dr. Kyu-Seok Yeon

Keynote speech

1. International cooperation for improvement of paddy field ecosystem (Prof. Sun-Joo Kim, Konkuk Univ., Korea)
2. Necessity and methods for participatory irrigation management (Prof. Masayoshi Satoh, Univ. of Tsukuba, Japan)

Session 1: Climate change and food security with sustainable agriculture

(Moderator: Mr. Dominado Pascua, Dr. Seung Heon Lee)

1. Climate change and sustainable agriculture (Zaliah B. Selamat, National Hydraulic Research Institute, Malaysia)
2. Reformation of paddy irrigation system in mountainous area under reconstruction of the fiscal economy and falling birthrate (Tanji Hajime and Hirohide Kiri, National Institute for Rural Engineering, Japan)
3. Mainstreaming climate change adaptation in irrigated agriculture for paddy farming in China (Xiaoling Wang and Minzhang Sun, Ministry of Water resources, P.R. China)
4. Changes of agro-climatic environment and evaluation of rice yield under climate change scenarios in Korea (Kyo-Moon Shim and Deog-Bag Lee, National Academy of Agricultural Science, Korea)
5. Stochastic risk assessment of the impact of climate change on annual typhoon rainfall under synthetic scenarios (Ke-Sheng Chen, Ju-Chen Hou, and Yii-Chen Wu, National Taiwan University, Taiwan)

Session 2-1: Sustainable irrigation techniques (Moderator: Dr. Kazumi Yamaoka, Dr. Myung Chul Eom)

1. Participatory irrigation management under the public system in Korea (SungHee Lee, TaiCheol Kim and Masayoshi Satoh, Rural Research Institute, Korea)
2. Sustainable irrigation techniques (Va-soon Boonkird, Honorable advisor, Royal Irrigation Department, Thailand)
3. Resource Conservation Technologies (RCTs) for sustainable irrigated agriculture of Pakistan (Asjad Imitaz Ali, Ministry of Water & Power, Pakistan)
4. Results of urban wastewater treatment reusing for agriculture: a case study in Lim Town, Bac Ninh Province, Vietnam (Nguyen Quang Trung and Hoang Thu Thuy, Vietnam Academy for Water Resources, Vietnam)
5. Sustainable water use and policies in the near East North Africa region-case of Egypt (Badawi A. Tantawi and Shimaa A. Badawy, Agricultural Research Center, Egypt)
6. Irrigated agriculture status and prospect in Philippines (Dominado Pascua and Leonor P. Fernandez, Philippines National Committee of ICID, Philippine)

Session 2-2: Sustainable paddy environment and irrigation techniques (Moderator: Prof. Chun-Gyeong Yoon)

1. An Inverse modeling to estimate unsaturated hydraulic conductivity in mixed form Richards equation (Tomoki Izumi, Masayuki Fujihara and Junichiro Takeuchi, Ehime University, Japan)
2. Development of wireless automated irrigation control system (Satyato K. Saptomo, Budi I. Setiawan, Lolly Martina Martief, and Hanhan Ahmad Sofiyuddin, Bogor Agricultural University, Indonesia)
3. Effects of different methods of methane fermentation digested Liquid into the paddy plot on soil nitrogen and rice yield (Satoko Watanabe, Kimihito Nakamura, Chan Seok Ryu, and Shigetō Kawashima, Kyoto University, Japan)
4. Estimation of crop virtual water in Korea (Seung-Hwan Yoo, Jin-Yong Choi, Taegon Kim, Seoul National University, Korea)
5. Carbon sequestration and nitrogen cycle on different cropping systems in Red River Delta (Mai Van Trinh, Institute for Agricultural Environment (IAE), Vietnam)

Poster session

1. Crop coefficient of paddy field under tropical system of rice intensification (T-SRI) environment (Chusunul Arif, Hanhan A. Sofiyuddin, Lolly M. Martief and Budi I. Setiawan, Indonesia)
2. Effect of micro-advection effect on the soil water transfer in the micro-irrigated fields (Kozue YUGE, Mitsumasa ANAN and Yoshiyuki SHINOGLI, Japan)
3. Effect of floating culture system on wind-Induced flow in closed waters (Kunihiko Hamagami, Masayuki Fujihara, Hidekazu Yoshioka, Sho Nakatake, Ken Mori and Yasumaru Hirai, Japan)
4. Spatio-temporal variability of soil physical properties in different potato ridge designs in relation to soil erosion and crop production (Krissandi Wijaya, Budi Indra Setiawan and Tasuku Kato, Indonesia)
5. Water balance analysis for the assessment of water availability in a small scale reservoir (O. B. A. Sompie and, Budi Indra Setiawan, Indonesia)
6. Carbon Organic in Vietnamese soils as affected by soil types cropping systems and material cycling (Pham Quang Ha and Mai Van Trinh, Vietnam)
7. Soil and baby corn yield improvement as influenced by organic fertilizers (Arawan SHUTSRIRUNG, Thailand)
8. Adaptation of agricultural reservoir by future climate change impact on watershed hydrology (Geun Ae Park, Jong Yoon Park, Hyung Jin Shin, Min Ji Park, Ji Wan Lee and Seong Joon Kim, Korea)
9. Improvement SWAT Auto-Calibration for Accuracies in High and Low Flow Regime Using K-means Algorithm (Hyunwoo Kang, Youn Shik Park, Jonggun Kim, Won Seok Jang, Ji Chul Ryu, Nam Won Kim, Dong Su Gong and Kyoung Jae Lim, Korea)
10. Enhancement of the SWAT-REMM system for simulation of total nitrogen reduction efficiency with riparian buffer system (Jichul Ryu, Jae-Pil Cho, Ik-Jae Kim, Yuri Mun, Jong-Pil Moon, Namwon Kim, Seong-Joon Kim, Dong Soo Kong and Kyoung Jae Lim, Korea)
11. Case study of allocating paddy water between inside and outside watersheds using weir and tunnel in Korea (Jaekyoung Noh, Jaenam Lee and Yongkuk Kim, Korea)
12. Analysis on landscape pattern change and ecosystem services value in the gap-stream watershed of South Korea (Moonseong Kang, Seungjong Bae, Inhong Song and Jinyoung Choi, Korea)
13. Spatial Analysis of Irrigation Rate in Taiwan (Ling-Fang Chang, Taiwan)
14. Sensitivity analysis of parameters of SSARR model during low flow on Geum River in Korea (Seungjin Maeng, Hyungsan Kim and Seungwook Lee, Korea)

Development of Wireless Automated Irrigation Control System¹

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The aim of this research is to develop an automation system for irrigation to be implemented on existing irrigation facility. Implementations of this system are in the experimental production land for organic farming developed at IPB Campus, which uses piping system for water transmission and at experimental irrigation station. The system is also implemented in the research on modernization of irrigation in Indonesia, collaborated with Ministry of Public Works. The control system uses water level detection as input and operates the irrigation by using electric valve to open or close irrigation inlet.

There are two systems that are being developed for the implementation, both incorporating wireless communication technology. The first system used cellular based communication system (GSM) to provide long range irrigation control system (Fig. 1.a), and the second one used wireless sensor network system (Fig. 1.b) with much shorter range (up to 500 m from controller to control point device).

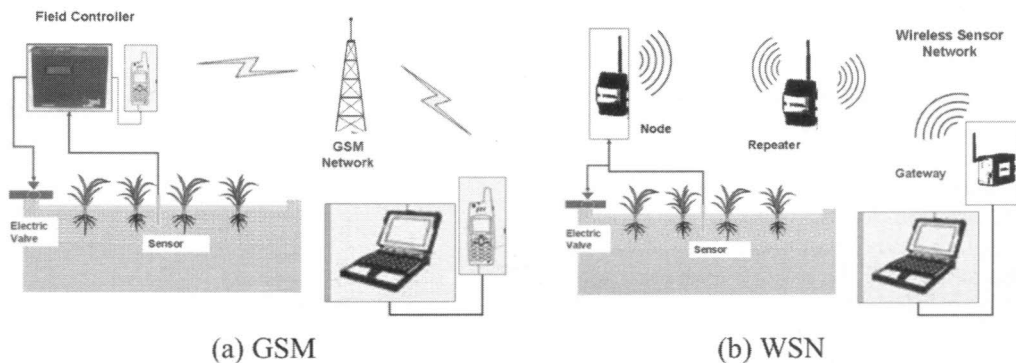


Fig. 1. Wireless Irrigation Control System

In the first system, automation is made possible by using field controller to operate the valve that was programmed to act to keep water condition at the field as expected to provide suitable water condition, to record data from sensors and irrigation activity. Apart from the microcontroller a computer is prepared as main controller to monitor the control activity and regularly download data from the field controller. Additionally the computer can also send command to the microcontroller if changes should be made in the field controller. The communication between main controller and field controller is established by using cellular communication system, enabling flexible location of field controller implementation.

¹ Extended abstract prepared for INWEPF-PAWEES Joint Symposium, Jeju Island, Korea 2010.

The later system is similar to the first one, except that the wireless communication is made possible by using *Gateway* and *Nodes*. Computer, programmed as controller, communicate wirelessly to the Nodes attached with sensors and valves through Gateway. Nodes will collect data from sensors and will act to control the valves based on instruction sent from the computer. The instruction is the result of the control program that is run in the computer.

Both systems experience delays in response, starting from acquiring data, sending data to the computer, processing the data, sending control instruction and the movement of the valves. As the field is being irrigated, water level rises slowly and after irrigation the water decreases even slower. This cause the input signal sensed by the sensor varies slowly and thus the sampling resolution can be lowered to minutes scale for example, which in turn can be considered to adjust the system operation for lowering power consumption. Communication cost is also need to be considered in the GSM system, which is directly proportional to the length of connection time used in the operation. These issues suggest the need of efficiency in the connection.

Therefore, timer control was introduced in the development of the system. The timer control is also the solution for the open-close operation of the valve. Since the valve is an on-off device, it needs to be open for a certain time to discharge sufficient amount of water to maintain the water level. Fuzzy Control is used to adjust the timer, which then is called Fuzzy Timer Control (FTC) in this research. In summary, the control system gives output of 1. On/off of irrigation (or drainage) valve and 2. Length of operation time, which decide how long the valve will open or close and also how long until the computer connect to the field controller (in GSM case) again.

Table 1. Valve Operation U_{op}

U_{op}	Irrigation	Drainage
1	on	off
0	off	off
-1	off	on

Control signal U_k is the output of FTC, which relation between U_k , U_{op} and t_{op} is as follows.

$$U_k = U_{op} * t_{op} \quad (1)$$

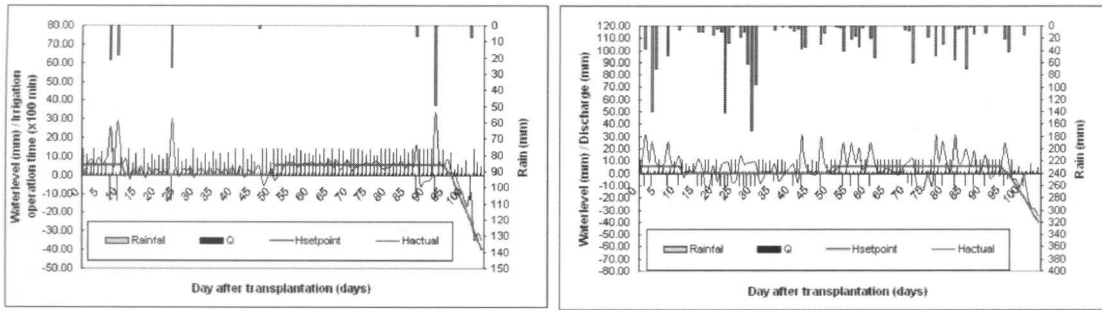
The result of the FTC is the sign (+/-) and operation time (Table1.). This system was used in simulation of water control, the simulation was based on water balance model

$$HP_t = HP_{t-1} + RF_t \pm Q_t - ET_t - P_t - RO_t \quad (2)$$

where ,

- HP_t = water level/water table in the field at day t (mm)
- HP_{t-1} = water level/water table in the field at day t-1 (mm)
- Q_t = irrigation (+) or drainage (-) at day t (mm)
- ET_t = Evapotranspiration (mm)
- P_t = Percolation (mm)
- RO_t = Surface run-off (mm)
- t = time (day)

The results of the control system are as depicted in Fig. 2. Table 2 shows the behavior of FTC during the simulation. Here it is shown that the FTC works for controlling the irrigation as expected, but has limited performance in maintaining water level at a certain level, especially in the extreme case of rainfall or in a heavy rainy period.



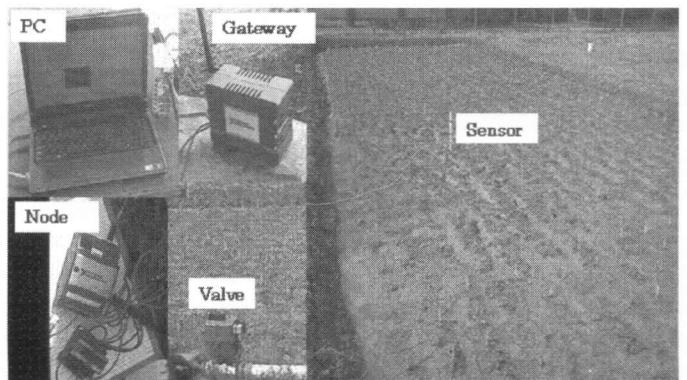
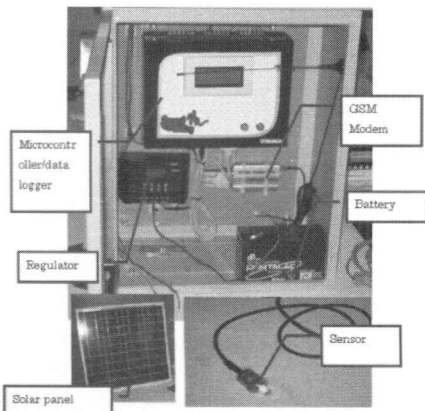
(a) Dry Season (b) Wet Season

Fig 2. Water balance simulation using FTC irrigation control

Table 2. Uk, top dan Qtotal of an example of simulated water level control operation

T (Day)	Uk	top (x100 min)	Irr	Drain	Q (mm)	Uk	top (x100 min)	Irr	Drain	Q (mm)
Dry Season						Rainy Season				
0	1.00	14.40	1.00	0.00	14.09	1.00	14.40	1.00	0.00	11.07
1	0.79	11.41	1.00	0.00	11.16	-1.00	14.40	0.00	1.00	-11.07
2	0.43	6.13	1.00	0.00	6.00	0.49	7.11	1.00	0.00	5.47
3	1.00	14.40	1.00	0.00	14.09	-1.00	14.40	0.00	1.00	-11.07
4	0.39	5.66	1.00	0.00	5.54	0.10	1.48	1.00	0.00	1.14
5	0.90	12.89	1.00	0.00	12.61	1.00	14.40	1.00	0.00	11.07
50	1.00	14.40	1.00	0.00	14.09	1.00	14.40	1.00	0.00	11.07
51	1.00	14.40	1.00	0.00	14.09	1.00	14.40	1.00	0.00	11.07
52	1.00	14.40	1.00	0.00	14.09	0.45	6.54	1.00	0.00	5.03
53	0.76	10.97	1.00	0.00	10.73	-1.00	14.40	0.00	1.00	-11.07
54	0.83	11.97	1.00	0.00	11.71	0.93	13.42	1.00	0.00	10.32
55	0.76	10.89	1.00	0.00	10.65	-1.00	14.40	0.00	1.00	-11.07

The wireless control system for Irrigation has been tested in a short trial for the WSN system. The GSM system has not yet been tested because of some problems in the preparation of the experimental land. Fig. 3. shows the pictures of the two systems prepared for testing.



Experiment at Experimental Station for Irrigation, Water Resource Research Center

(a) (b)

Fig 3. Wireless control system prepared for research and education facility at IPB (a) and Experimental Station for Irrigation (b)