ENGINEERING FOR BETTER WATER MANAGEMENT

Water Resources Engineering

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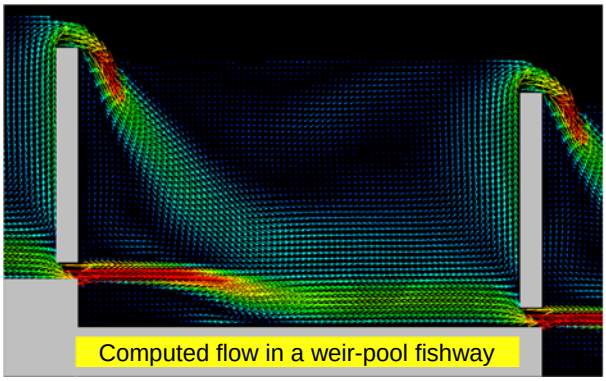
Water is a key medium for understanding interaction between mankind and the environment. Our laboratory applies engineering disciplines to management of water resources in rural areas, equally emphasizing theoretical developments, field studies, laboratory experiments, and numerical computations.

Theoretical fundamentals

Mathematical methods are consistently applied for discussing better management of water resources. Current research topics include but not limited to physicochemical interaction between soil and water, hydrological processes in rural watersheds, dynamics of aquatic ecosystems, degenerate diffusion processes, and feedback control of water storage systems. Our laboratory has an integrated hydraulic experimental station.



Computed flow in a weir-pool fishway

Study fields

Several study fields are set for implementing surveys and observations to evaluate developed models. Few examples are introduced here. Being a part of Lake Biwa Basin of Japan, Koka area mostly consists of forest watersheds, tea plantations, irrigated paddy fields, and urbanized zones. Optimal farming practices are proposed in order to protect sound downstream water environment. A prototype irrigation scheme including a reservoir for harvesting flash floods is being developed in a harsh environment near the Dead Sea of Jordan. Pioneering studies are being conducted to support sustainable irrigation agriculture in arid regions of the Middle East. There are other study fields in Japan, India, Bangladesh, Malaysia, and Ghana.

Catchment area / hydraulic structures / desalination plant / command area of the irrigation scheme developed in Jordan

Numerical analysis

Computational fluid dynamics (CFD) techniques such as finite element method (FEM), finite volume method (FVM), and pore network model are used for simulating flow fields of surface and subsurface water as well as transport phenomena occurring there. Design of hydraulic structures and assessment of water environment are major applications of CFD. However, CFD techniques are further applied to different optimal control problems, which are based on the principle of optimality in dynamic programming.

Optimization

Management of water resources involves making decisions to achieve certain goals related to human welfare. Optimal strategies are considered for controlling floods, improving agricultural production, and protecting water quality environment including aquatic biota. Optimization models derived from mathematical programming and optimal control theories serve as decision support tools for water management practices. A large computational effort is required in dynamic programming as well as in robust optimization.

Key words

Runoff Processes, Irrigation and Drainage, Micro-Dams, Aquatic Biota, Hydraulic Experiment, Water Quality Environment, Computational Fluid Dynamics, Porous Media, Stochastic Processes, Mathematical Programming, Optimal Control

Recent publications

Stochastic optimal control of agrochemical pollutant loads in reservoirs for irrigation
Mabaya G, Unami K, Fujihara M (2017)
Journal of Cleaner Production 146:37-46

Modeling of permeability of porous media with mixed wettabilities based on noncircular capillaries
Takeuchi J, Tsuji H, Fujihara M (2017)
International Journal of GEOMATE 12(34):1-7

Verifying optimality of rainfed agriculture using a stochastic model for drought occurrence
Sharifi E, Unami K, Yangyuoru M, Fujihara M (2016)
Stochastic Environmental Research and Risk Assessment 30(5):1503-1514

Modeling of fluid intrusion into porous media with mixed wettabilities using pore-network
Takeuchi J, Sumii W, Fujihara M (2016)
International Journal of GEOMATE 10(4):1971-1977

Numerical analysis on the occurrence of thermal convection in flowing shallow groundwater
Takeuchi J, Kawabata M, Fujihara M (2016)
International Journal of GEOMATE 11(5):2688-2694

Robust optimal diversion of agricultural drainage water from tea plantations to paddy fields during rice growing seasons and non-rice growing seasons
Mabaya G, Unami K, Yoshioka H, Takeuchi J, Fujihara M (2016)
Paddy and Water Environment 14(1):247-258

A dual finite volume method scheme for catastrophic flash floods in channel networks
Yoshioka H, Unami K, Fujihara M (2015)
Applied Mathematical Modelling 39(1):205-229

Stochastic modelling and control of rainwater harvesting systems for irrigation during dry spells
Unami K, Mohawesh O, Sharifi E, Takeuchi J, Fujihara M (2015)
Journal of Cleaner Production 88:185-195

A finite element/volume method of the depth-averaged horizontally 2-D shallow water equations
Yoshioka H, Unami K, Fujihara M (2014)
International Journal for Numerical Methods in Fluids 75(1):23-41

Sub-Darcy-scale modeling of non-uniform flow through porous media with mixed wettabilities
Takeuchi J, Takahashi T, Fujihara M (2014)
International Journal of GEOMATE 6(2):840-847

Stochastic control of a micro-dam irrigation scheme for dry season farming
Unami K, Yangyuoru M, Alam AHMB, Kranjac-Berisavljevic G (2013)
Stochastic Environmental Research and Risk Assessment 27(1):77-89