Commentary
Volume 12:01, 2023

Irrigation & Drainage Systems Engineering

ISSN: 2168-9768 **Open Access**

2D High-Resolution Modeling for Simulating and Enhancing Border Irrigation Management

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Description

In this work, the structure of a framework for integrated hydrodynamic modeling that is meant to describe the dynamics of surface irrigation is shown. In particular, the high-resolution topographic data of the ground surface, two-dimensional shallow water equations, and a one-dimensional Green-Ampt approach for describing the infiltration process comprise the modeling framework known as IrriSurf2D. A real-world case study was used to validate the modeling framework. During a border irrigation event, timings of waterfront advance and field water depths were tracked. The findings demonstrate that IrriSurf2D was successful in accurately reproducing the timings of waterfront advance and the maximum water depth, with average RMSEs of less than 2 minutes and 3 centimeters, respectively. Without a custom calibration of the infiltration and roughness parameters, model performance was reliable and accurate even when using parameters from the literature. The description of waterfront propagation was significantly influenced by particulars of the digital terrain model that have an effect on the computational grid resolution: It was discovered that a coarse grid resolution of $1 m^2$ was insufficient for reproducing accurate timings of waterfront advance and water depths in the field; however, when a finer grid resolution of $0.01\ m^2$ was used as the modeling input, the simulation results appeared to be appropriately in line with the observations. The modeling strategy paves the way for the creation of an operational tool for enhancing surface irrigation management and appears promising for describing the dynamics of border irrigation [1].

The oldest and most widely used method of irrigation worldwide is surface irrigation. Surface irrigation is used on 97% of India's irrigated land (approximately) according to Aquastat data from the Food and Agriculture Organization. 60.8 Mha), or 94 percent in China (roughly 57.8 Mha), representing 44% (approximately 22.4 Mha) and 100 percent in Pakistan (roughly 19.6 Mha). This method of irrigation is most common in the Padana Plain, the largest irrigated plain in the EU with approximately 4.7 Mha of irrigated land, where surface irrigation is used to largely water irrigated land. Border irrigation is the most common type of surface irrigation for row crops worldwide. Border irrigation often suffers from high inefficiency due to over-irrigation and poor application uniformity. In the border irrigation method, water flows down the slope by utilizing only gravity. When the desired amount of water has been delivered to the field, the stream is turned off, which may occur before the water has reached the entire field. Despite the fact that this irrigation method continues to attract the attention of researchers due to its low operating and maintenance costs (e.g., very low energy consumptions in comparison with pressurized systems), border Even though they should be considered merely indicative and the farmer's experience should be used to determine how to calculate cutoff time based on soil characteristics, literature contains guidelines. In addition, the farmer's experience serves as a guide for the land preparation prior to the irrigation season, particularly in terms of slope and strip width. They discovered that the correct application of these "geometrical variables" is crucial to increasing the effectiveness of border irrigation practice's water use. Therefore, effective border irrigation systems necessitate effective design and management, both of which can be addressed with the help of specialized modeling tools [2].

For the purpose of describing the dynamics of border irrigation, this work proposes a novel integrated modeling framework based on the combination of hydrodynamic modeling and on-field measurements. More specifically, the structure of the modeling framework in this work is made up of (i) high-resolution topographic data, (ii) two-dimensional surface hydrodynamic modeling, and (iii) semi-physical infiltration modeling, both of which will be described and tested. A tool that could assist in the management of border irrigations at the field scale is provided by the proposed strategy, which overcomes the simplifications caused by (i) the one-dimensional description of the water front advance, (ii) the empirical representation of the infiltration processes, and (iii) the flat delineation of the ground surface. By comparing modeling outputs with observations obtained in a real-world case study where border irrigation events were accurately monitored during the 2022 agricultural season, performance of the proposed method has been estimated in terms of its ability to describe (i) the times of the waterfront advance and (ii) the actual water depths along the longitudinal direction of the field during irrigations [3].

During irrigation events, proper management of the distribution of water onto the field can help reduce water consumption and ensure that crop watering is consistent with its requirements. An ideal combination of flow rate, cutoff time/distance, field/strip size, and slope should be investigated in the context of border irrigations to achieve this objective. The proposed modeling framework gives you a useful tool for looking at how different combinations of these variables affect how well border irrigations work as a whole. It improves the description of surface water dynamics on borders by combining information on microtopography, infiltration, and hydrodynamics and making use of direct on-field measurements when they are available. The main parts of the modeling framework are shown in the next section [4,5].

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Received: 02 January 2022, Manuscript No. idse-23-88362; **Editor assigned:** 05 January 2022, PreQC No. P-88362; **Reviewed:** 16 January 2022, QC No. Q-88362; **Revised:** 21 January 2022, Manuscript No. R-88362; **Published**: 30 January 2022, DOI: 10.37421/2168-9768.2022.12.369

Acknowledgement

None.

Conflict of Interest

None.

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How to cite this article: Costabile, Pierfranco. “2D High-Resolution Modeling for Simulating and Enhancing Border Irrigation Management.” *Irrigat Drainage Sys Eng* 12 (2023): 369.