Evaluation of different scenarios to optimize the delineation of daya surfaces using the multi-bandwater index (MBWI)

Rachid Boutafoust (1), Abdelmejid Rahimi (1), Abdelkrim Bouasria (1, 2)

(1) Geodynamics and geomatics Laboratory, Faculty of sciences, Chouaïb Doukkali University, El Jadida, Morocco. (2) Agmetrix, El Jadida, Morocco

Introduction

Inland surface water bodies are vital components of the Earth system. Sustainable management of these water resources involves monitoring changes in surface water. (Xing et al., 2022) (Liu et al., 2023).

Monitoring and mapping surface water using remote sensing from space has become an essential alternative, especially with the development of the (GEE) platform (Atay & Kaplan, 2023)

The performance of remote sensing methods for extracting surface water is still unknown

Study area

The Doukkala plain, characterised by the presence of temporary surface waters known locally as dayas

These dayas serve a very vital socioeconomic and ecological significance.

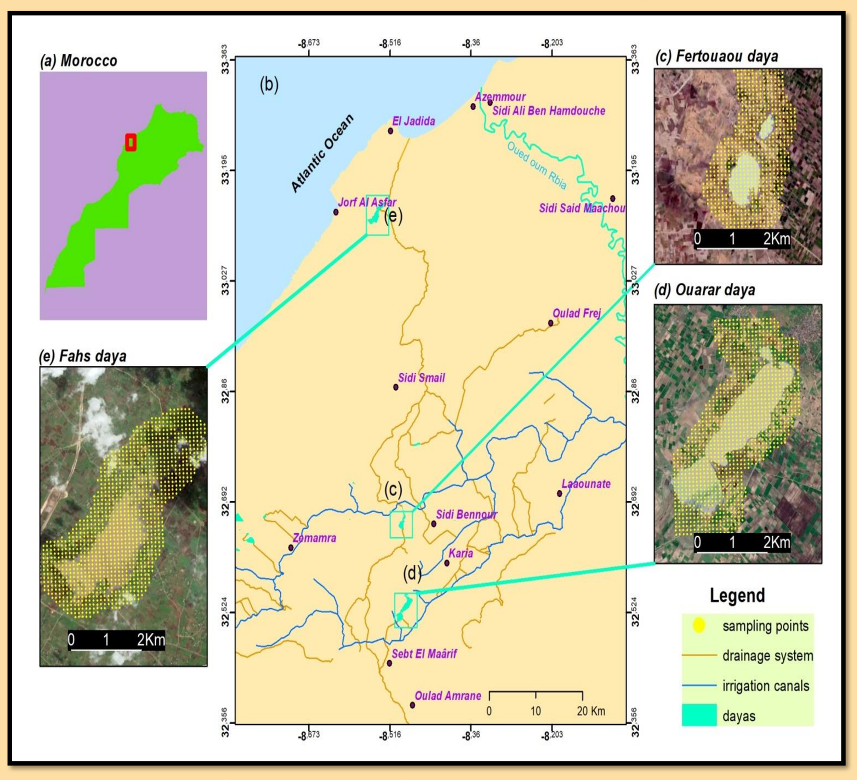

Figure 1. Location of the test site in study area

Water index

Widely used methods (water extraction using remote sensing)

- *The reflectance of the Earth's surface in different spectral bands, from visible to short-wave infrared;*
- *Identifying a threshold is the most important step;*
- *The stability of an optimal threshold means that a single value is valid over several scenes in time and space.*

MBWI is a water index validated on Landsat 8 images.

- *The MBWI formula includes a three weighting factors ω , the values 2, 3, and 4 of ω have been retained for this index, however the value 2 better maximizes the difference between water and non-water surfaces. (Wang et al., 2018);*
- *Many studies have used this index, some with a weighting of 2 (Liu et al., 2023) (Atay & Kaplan, 2023), others with a weighting of 3 (Qin et al., 2023)*

We used the (GEE) platform to compare the performance of the (MBWI) index applied to three principal Daya in the region.

Objective

Find the most accurate and stable MBWI weighting factors in our study area to monitor the dynamics of these surface waters.

Methodology

Cases studies

5 cases studies were chosen for the MBWI evaluation based on the availability of Google Earth Pro and Landsat images

Reference data

Systematic sampling points on a square grid, 90 metres apart, covering each of the three dayas with a buffer of 500 metres around their perimeters.

	Fahs		Ourar		Fertouaou
	December 2018	January 2015	January 2009	November 2018	June 2011
Water	95	436	459	375	98
No water	1125	776	703	782	740

Table 1. Number of sample points

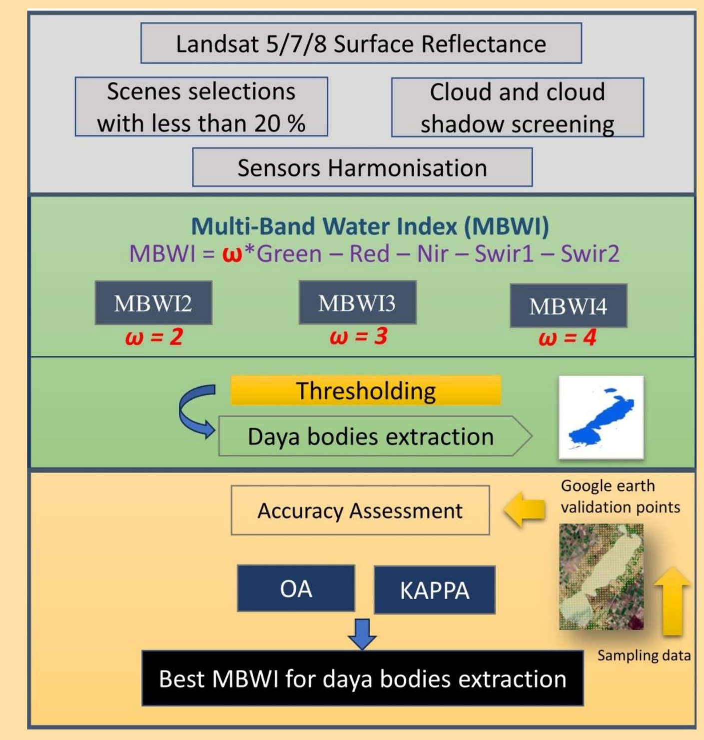

Figure 2: Schematic summary adopted in this study

Calculation of MBWI

	Equation
MBWI2	2 × GREEN − RED − NIR − SWIR1 − SWIR2
MBWI3	3 × GREEN − RED − NIR − SWIR1 − SWIR2
MBWI4	4 × GREEN − RED − NIR − SWIR1 − SWIR2

Table 2. MBWI equations used

Evaluation of water extraction accuracy

1- Visual evaluation of the extracted maps

2- Confusion matrix

Compare extracted water & no water maps with reference data.

Overall accuracy (OA): *Near 1 accurate and reliable classification*

Coefficient kappa (kappa): *For medium spatial resolution, such as Landsat, Kappa greater than 0.75 is considered acceptable (Atay & Kaplan, 2023) .*

Determining and evaluating thresholds

- Thresholds iteratively using two distinct step values (0.1 and 0.01).
  - to find the highest OA and kappa
- To obtain a fixed threshold, the average of the optimal thresholds found will be evaluated for each factors
  - The best performing and most stable MBWI on the five cases

Results

Determining thresholds

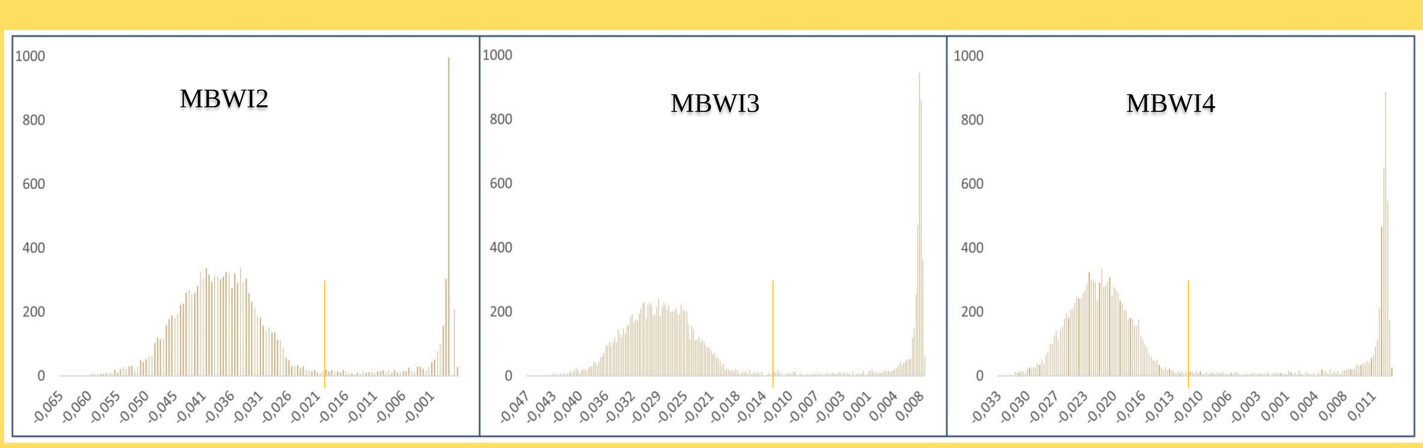

Figure 4: Histograms of Daya Ouarar in November 2018

Generally allow two peaks to be identified, one for the part containing water and the other for the part not containing water..

For MBWI, the right-hand peak corresponds to the highest water values

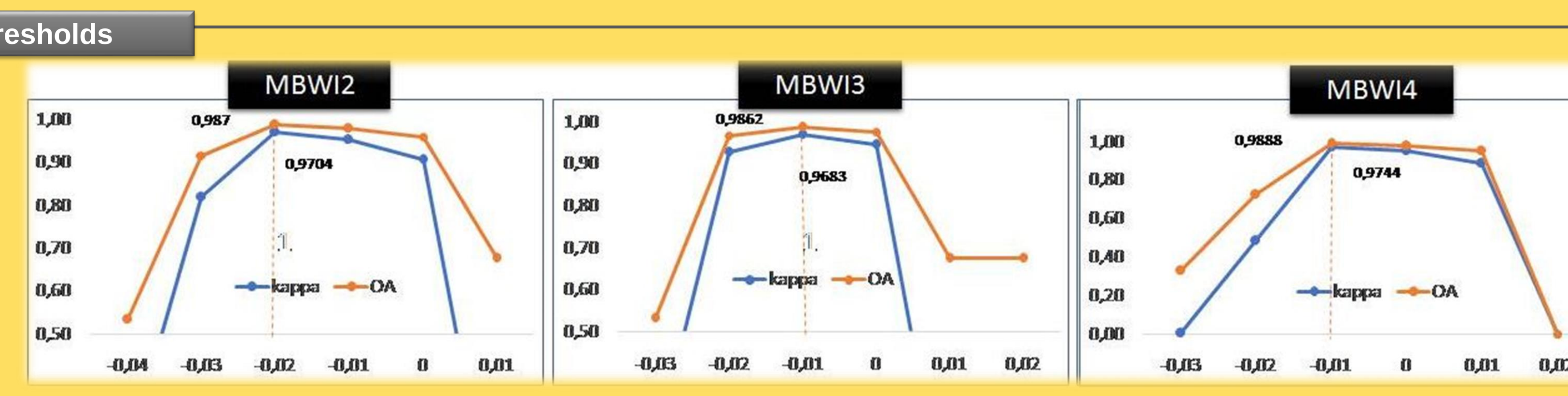

Figure 3. Overall accuracy (OA) and kappa coefficient (kappa) using segmentation thresholds for the Daya Ouarar case in November 2018..

	MBWI2	MBWI3	MBWI4
Fartouaou June 2011	-0,03	-0,02	-0,01
Fahs december 2018	-0,01	-0,01	0
Fahs January 2015	-0,01	-0,01	-0,01
Ouarar July 2009	-0,03	-0,02	-0,01
Ouarar November 2018	-0,02	-0,01	-0,01
Average	-0,020	-0,014	-0,008

Tableau 3. Seuils optimaux d'extraction de l'eau pour les cinq cas d'étude.

Interclass separability analysis

Optimal threshold

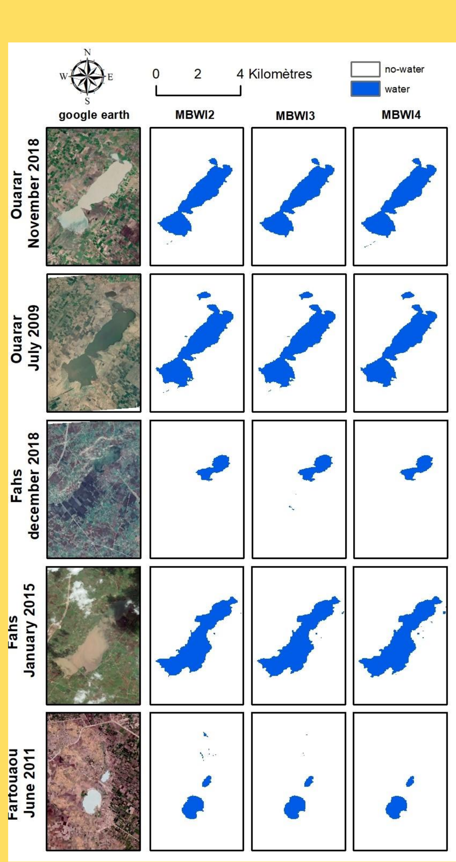

Figure 5 . Water extraction maps of the study based on MBWI with optimal thresholds.

Visual inspection

The separation between the water and non-water classes has been correctly carried out *(MBWI2, MBWI3 and MBWI4)*

	MBWI2		MBWI3		MBWI4	
	OA	Kappa	OA	Kappa	OA	Kappa
Ouarar November 2018	0,99	0,97	0,99	0,97	0,99	0,97
Ouarar July 2009	0,98	0,95	0,98	0,95	0,97	0,94
Fahs december 2018	0,99	0,96	0,99	0,96	0,99	0,93
Fahs January 2015	0,99	0,97	0,99	0,98	0,99	0,97
Fartouaou June 2011	0,99	0,95	0,99	0,97	0,99	0,95

Table 4. Evaluation of the precision (OA & Kappa) optimal threshold

OA

All performances near 1 (0.97 to 0.99)

Very high water prediction

Kappa

All performances over 0.9 (0.93 to 0.98)

High precision water extraction

Average optimal threshold

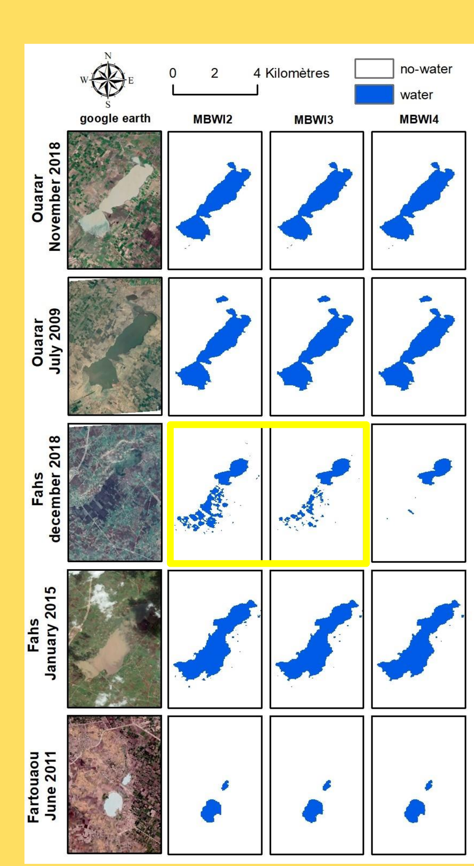

Figure 6. Water extraction maps of the study area based on MBWI with optimal mean thresholds.

Visual inspection

The separation between the water and non-water classes was not good for *MBWI2 et MBWI3 (Fahs Dec 2018)*

	MBWI2		MBWI3		MBWI4	
	OA	Kappa	OA	Kappa	OA	Kappa
Ouarar November 2018	0,99	0,97	0,99	0,97	0,99	0,97
Ouarar July 2009	0,96	0,93	0,97	0,93	0,97	0,93
Fahs december 2018	0,86	0,46	0,93	0,66	0,99	0,95
Fahs January 2015	0,98	0,96	0,99	0,98	0,99	0,97
Fartouaou June 2011	0,98	0,91	0.99	0,93	0,98	0,92

Table 5. Evaluation of precision (OA & Kappa) average optimal threshold

OA & Kappa

MBWI4 *five scenes*
- OA near 1 (0.97 to 0 ,99)
- Kappa coefficient over 0.9 (0.92 to 0.97)

→ High precision water extraction

MBWI2 & MBWI3 *Fahs Dec 2018*
- OA 0.86 and 0.93 respectively
- Kappa coefficient less than 0.75

→ Low water extraction accuracy

Conclusion

- ***The visual analysis of the maps derived from the extraction of the water class using the selected thresholds was confirmed by the OA and Kappa performances;***
- ***The extraction of the water class using the optimal thresholds of the three weighting factors 2, 3 and 4 of the MBWI index showed good accuracy, with OA performance close to 1 and Kappa greater than 0.9;***
- ***The results show the combination of the weighting coefficient 4 and the threshold -0.008 yielded better performances with a Kappa between 0.92 and 0.97 for the five scenes.***
- ***To assess the accuracy of this index combined with the thresholds set, this assessment needs to be supplemented by an analysis of the dynamics of these surface waters over a series of Landsat images.***

References

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