Analysis and Prediction of Land Cover Changes (Hable-Rud, Iran)

Sajad Khoshnoodmotlagh[1,2*], Amin Haghnegahdar [1], Saman Razavi [1], Amir Sadoddin [2]

[1]Global Institute for Water Security, University of Saskatchewan, [2]Department of Watershed management, University of Gorgan, Iran

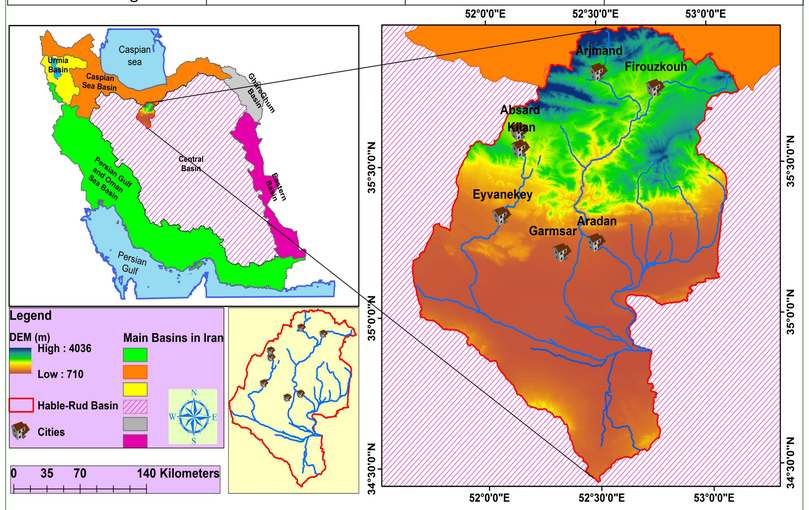
UNIVERSITY OF SASKATCHEWAN
Global Water Futures
GLOBAL INSTITUTE FOR WATER SECURITY
GWF.USASK.CA

Background and Objectives

- LC/LU is an important indicator in understanding the interactions between human activities and the environment (Dewan, Yamaguchi, & Rahman, 2012)
- Land cover (LC) refers to the biophysical attributes of the earth's surface and immediate subsurface (Billie Turner, R. H. Moss,1993).
- Land use (LU) is a description of how people utilize the land for their needs by various management practices (Fisher, P., Comber, A., Wadsworth, 2005; IPCC, 2000).
- The primary objective of this study is to analyze and predict decadal changes in land cover using Landsat ETM+ and TM images and Land Changing Model (LCM) model for the period 1986–2040.
- Probability matrices and land cover area changes are obtained using a Markov Chain model.

Study Area

Feature	Describe and value	Feature	Value and type (unit)
Interest Area	Hable-Rud, Iran	Precipitation	314 mm
Latitude	51° 39' to 53° 8'	Population	157168 person
Longitude	34° 26' to 35° 57'	Max elevation	4057 m
Area	1700 km^2	Min elevation	733 m
Main stream length	124 km	Mid elevation	1434 m



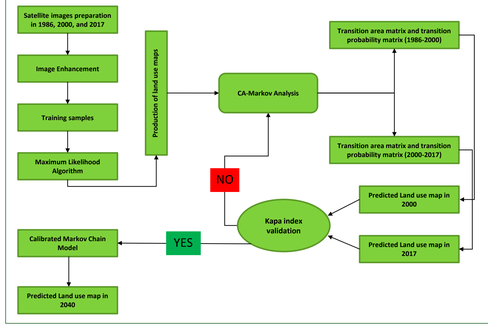
Methods

Data collection and research methods

Main steps:

1) Image preparation and processing
2) Image Geo-referencing and classification
3) Calculating Transition matrices and predict land cover maps in 2000 and 2017
4) Predicting land cover map in 2040 using the Cellular Automata (CA)-Markov model

Flowchart of the research methodology



Specifications of Landsat images(top) and Land cover classes delineated on the basis of supervised classification(bottom)

Dataset	Date	Source reference	Band number
Landsat 8 OLI* (path/row: 163/35, 163/36, 164/35 and 164/36)	July 16, 2017	WGS84	5,4,3,2
Landsat 7 ETM* (path/row: 163/35, 163/36, 164/35 and 164/36)	July 25, 2000	WGS84	5,4,3,2
Landsat 5 TM* (path/row: 163/35, 163/36, 164/35 and 164/36)	July 06, 1986	WGS84	4,3,2,1

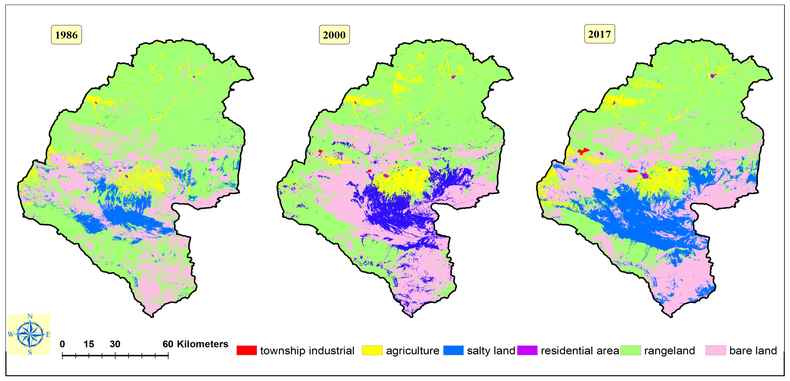
*: These data were collected from the official website of US Geological Survey (USGS) (https://earthexplorer.usgs.gov/).

Class name	Description
Agriculture area	Includes all farms and gardens
Rangeland	Includes all range lands and forest fields.
Bare land	Includes all land areas that are useless
Salty land	Includes all land areas that were covered by salt
Township industrial	Includes all industrial area.
Residential area	Includes all residential area (cities, village...)

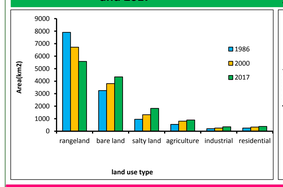
Result

Land cover classification for years 1986, 2000 and 2017

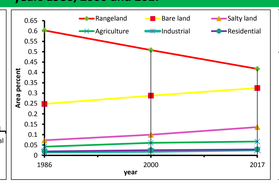
- Supervised maximum likelihood method using ENVI 5.1
- Classification accuracy verification (142 polygons for Landsat TM, 139 polygons for Landsat ETM, and 154 polygons for Landsat OLI are selected to evaluate the accuracy of classification)



Land cover classes area for 1986, 2000 and 2017



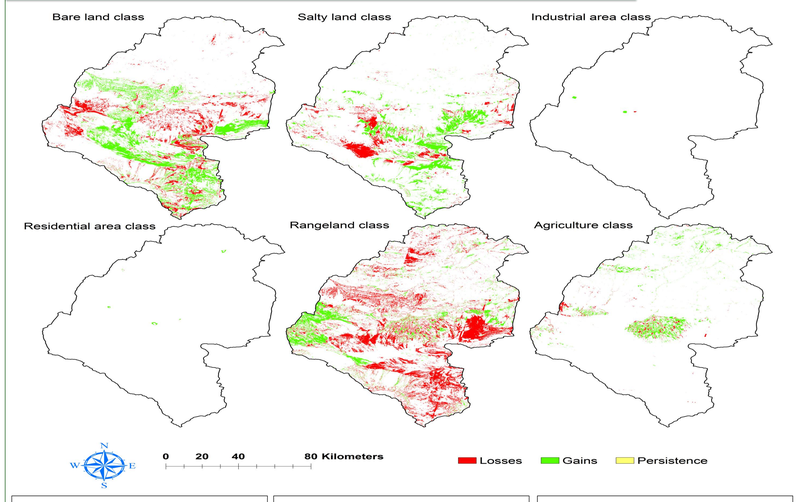
Trend of land cover classes during years 1986, 2000 and 2017

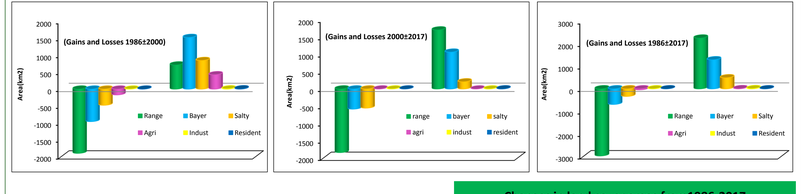


Classification accuracy verification values

Land cover type	1986 Producer's accuracy (%)	2000 Producer's accuracy (%)	2017 Producer's accuracy (%)
Rangeland	81.33	79.42	68.72
Bare land	79.12	87.28	83.39
Salty land	87.23	75.15	81.43
Agriculture	65.30	83.87	94.31
Industrial	68.71	76.18	76.16
Residential	73.42	69.75	63.86
Overall accuracy	84.13	87.14	93.78
Kappa index	0.756	0.788	0.811

Map of the Gains and Losses of different land cover classes from 1986 to 2017





Overall during 1986-2017 period:

- Rangeland area gains and losses are 40% and 53%, respectively.
- Bare land area gains and losses are 29% and 15%, respectively.
- Salty land area gains and losses are 26% and 18%, respectively.
- Rangeland area has decreased around 2323 km^2, while bare land, salty land, agriculture, industrial area and residential areas have increased by 1094 km^2, 868 km^2, 344 km^2, 150 km^2 and 130 km^2, respectively.

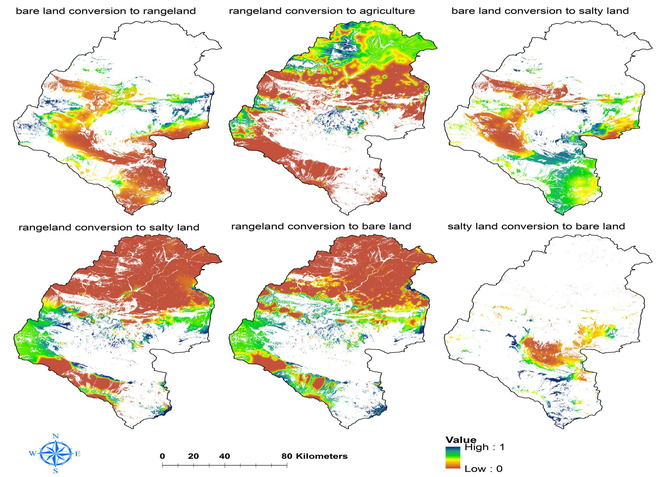
Changes in land cover areas from1986-2017

Land cover type	1986-2000 Area(km^2)	1986-2000 Area (%)	2000-2017 Area(km^2)	2000-2017 Area (%)	1986-2017 Area(km^2)	1986-2017 Area (%)
Rangeland	-1192.81	-0.15	-136.12	-0.02	-721.42	-0.13
Bare land	561.21	0.17	482.64	0.13	597.9	0.14
Salty land	366.6	0.38	-347.3	-0.26	154.58	0.08
Agriculture	251.69	0.46	-2.09	0.00	-37.79	-0.04
Industrial	5.74	0.03	0.05	0.00	6.79	0.02
Residential	7.57	0.03	2.83	0.01	-0.06	0.00

Discussion

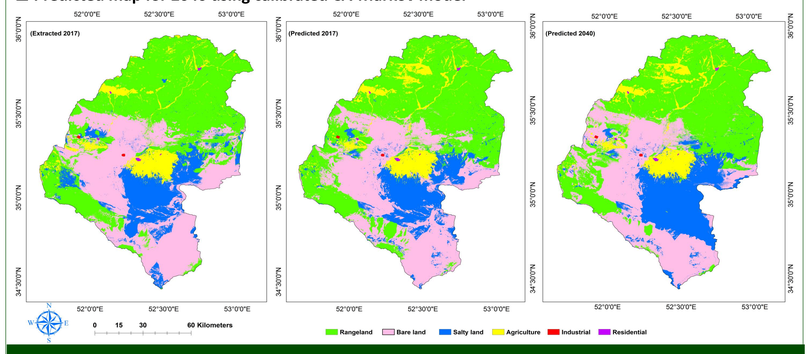
Transition probability maps of land cover during 1986 to 2017

- Define Sub models and use CA-Markov to identify pixels with highest probability of converting to a certain class in the target year and allocate it to that class



The extracted and predicted land cover classification

- Extract map from ENVI for 2017 (trained and using Maximum Likelihood method)
- Predicted map for 2017 using CA-Markov model in EDRISI TerrSet
- Predicted map for 2040 using calibrated CA-Markov model



Conclusions and Recommendation

- CA-Markov model was successful in predicting land covers in 2017 (kappa index = 74%).
- The patterns of land cover changes from 1986-2017 show that on the average rangeland decreased ~18%, while we see average increases for bare land by ~8.6%, salty land by ~6.8%, agriculture by ~2.7%, industrial area by ~63% and residential area by ~48%.
- According to the predicted results for 2040, the areas of rangeland and salty land will increase by ~6.5% and 2%, while the areas of bare land and agricultural land will decrease by ~6% and 2%, respectively.
- Degradation of Rangelands and increase of Salty lands and Bare lands in the Hable-Rud basin can be caused by excessive agricultural expansion and intensified by prolonged drought conditions in that area.
- One of the main challenges in simulating land cover using remote sensing images is co-existence of mountainous areas upstream and deserts downstream, which makes distinguishing certain land covers very hard in Landsat images.

References

1. Dewan, A. M., Yamaguchi, Y., & Rahman, M. Z. (2012). Dynamics of land use/cover changes and the analysis of landscape fragmentation in Dhaka Metropolitan, Bangladesh. GeoJournal, 77(3), 315–330. https://doi.org/10.1007/s10708-010-9399-x
2. Fisher, P., Comber, A., Wadsworth, R. (2005). Land Use and Land Cover: Contradiction Or Complement. Re-Presenting GIS, Pages 85-98.
3. IPCC, 2000. (2000). Special report on emissions scenarios. Working group III, Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, 595.
4. Billie Turner, R. H. Moss, D. L. S. (1993). Relating land-use and global land-cover changes. IGBP Report, No. 24. Retrieved from https://asu.pure.elsevier.com/en/publications/relating-land-use-and-global-land-cover-change-2

* Contact: sak926@usask.ca