Detecting Givi Chay River Channel Changes from 2000 to 2019

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1. Introduction

River and river processes are considered as the most significant geomorphic systems which are active on the earth's surface (Bag, 2019). Over time, many changes in the morphology and dynamics of the river system can occur. The effects of river adjustment caused by the natural factors require much longer time span to be revealed. However, there are few exceptions that the natural factors such as river floods, landslide or earthquake can induce channel adjustments in a very short time (Chaiwongsaen et al., 2019). On the contrary, human activities can have a significant and rapid impact on natural processes and trends, resulting in a compressed time scale for river adjustments (Rinaldi & Simon, 1998). Morphological responses may include subtle shifts in cross-sectional stream channel geometry or widespread landscape transitions, involving progressive or abrupt change over daily to millennial timescales. In order to sustainably manage river systems, it is necessary to further investigate the characteristics of variation in river morphology at various temporal and spatial scales (Minh Hai, 2019). Givi Chay River is one of the permanent rivers of Ardebil province in northwest of Iran and there is still no comprehensive study on this river. This study attempts to investigate the changes of morphological of the Givi Chay River over the time period 2000-2019.

2. Study Area

Givi Chay River with almost 54 kilometers is one of the permanent rivers of Ardabil province. Two rivers of Hiro (which is emanated from Khalkhal altitudes) and Arpa chay (which is emanated from north to south), are linked to each other in downstream and the stream around Inalava village is departed toward westward and between altitudes of Khalkhal and Givi reaches to Givi city through a narrow valley. In this area, that river is called Givi Chay. The river flows into Ghezelozan after crossing the city of Givi and joining the Firoozabad River.

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3. Materials and Methods

In this research, the topography map with a scale of 1:50000, geology map with a scale of 1:100000, and google earth and Landsat Eight images, including OLI sensor (2019), Landsat seven including ETM + sensor (2000), bedrock maps and the Givi Chay River privacy at a scale of 1:2000 hydrological data and field data were used. Moreover, to control the results obtained by quantitative methods it is used from field studies for confirmation and verification. ENVI 5.3, Arc GIS 10.5 and Excel software were also used for image processing and data analysis. The geomorphological parameters of the river and their variations including bending coefficient and central angle were measured. The curvature coefficient is one of the few criteria used in river shape segmentation using s=1/ (y.2), i.e., by dividing the valley length by wavelength for each arc (Pitts coefficient) which was calculated. The central angle of the arcs on each of the intervals was calculated using the relation $A=180L/R\pi$, where A is the central angle, R, of the fitted circle radius (Kornias coefficient). The lateral changes of the canal were investigated using transect method and calculation of river migration rate. According to the Transect method, lines with distinct distances from both sides of the duct are depicted as baselines. These lines are constant for the time periods studied and hence can be calculated quantitatively for duct movements relative to these lines. When the conduit is moved in the right direction, the area of the right-hand transect of the conduit decreases and is added to the area of the left-hand transect of the conduit, and vice versa. In this study, the Givi Chay River channel was divided into 23 transects based on morphology and channel change trends and quantitative indices were calculated for each transect. The $Rm = (A/L)/Y$ relation was also used to calculate the channel displacement rate. In this respect, RM stands for transverse displacement intensity, A for area between two centerline lines, L is centerline length at time t1 and Y is number of years.

4. Result and Discussion

The mean curvature coefficient for the first period in 2000 was 1.48 and decreased to 1.40 in 2019. But in other periods from 2019, the bending coefficient has increased compared to 2000, as the bending coefficient from 1.23 to 1.25 in the second period and from 1.85 to 1.86 in the third period and from 1/15 to 1/18 in the fourth quarter it increased. In general, the lowest bending coefficient for each period is in the fourth interval and in a finite amount. In the first, second, and fourth intervals, most of the intervals in both study periods have a curvature coefficient of 1.5-1.5 and therefore the conduit plan is sinusoidal, but in the third interval more than 60% of the range has a curvature of 1.5 to 2 and therefore the interval pattern is in the form of a Meander. In the second and fourth intervals, the standard deviation of the bending coefficient is low and in the second interval is 0.19 in 2000 and 0.18 in 2019 and in the fourth interval is 0.14 in 2000 and 0.12 in 2019. In general, they indicate the existence of similar arcs. In the first and third intervals, the standard deviation is relatively high for both periods, indicating non-similar arcs.

In both periods, the first and the third intervals were highly developed in the form of Meander and the fourth period were of the developed Meander type. However, during the second period during the period, the type of the rift from the developed meander changed to the highly developed meander and the central angle reached from 143.82 in 2000 to 163/50 in 2019. Due to the low valley bed and its alluvial slope, which is associated with complex mazes, and with increasing spiral arc and river energy concentration, the intensity of erosion reaches its maximum and where it is a maze arch, it is concentrated on both sides. A large amount of excipients flows into the bed. As the spiral energy intensifies, the width of the floodplain increases due to erosion. In the first interval, the central angle of the riverbed has decreased in 2019 compared to 2000, and with the decrease of the central angle of the river, the mean radius of tangent to the riverbed has also decreased and in other intervals has witnessed an increasing trend of the central angle during the study period. Increasing the central angle indicates that the river meanders are active and the morphology of the river has changed to a highly developed rudimentary twist, as well as a change in the central angle in bends that have not been removed and only changes have been made in it. In the third interval, the mean central angle in both periods is higher than other intervals. In fact, the river flows in a winding direction due to the geological resistance of the river and the low width resulting from this factor.

The maximum amount of lateral changes in transect 12 was 1.51 m and in this transect during the study period 5.47 hectares decreased from left bank and added to right bank. The lowest location in Transect 20 is 0.54 meters, thus reducing the left bank to 1.13 hectares and adding to the right bank of the river. Transverse displacements have often occurred in parts of the river course where the riverbed has floodplains, and the riverbed in these areas is significantly wider and the slope greatly reduced and widened significantly. Agricultural lands and gardens are visible in these areas.

5. Conclusion

According to the results of the calculation of morphological indices, the average bending coefficient in the first period decreased in 2019 compared to 2000, but the coefficient of bending increased in the 2nd, 3rd and 4th intervals. The first, second, and fourth intervals have sinusoidal plans in both study periods, but in the third intervals in both periods, the interval pattern is a meander. In terms of the central angle index, in the second interval during the study period, the type of interval changed from extended to highly develop. However, the first and third intervals, in both study periods, are highly developed in the form of a meander and the fourth period are in the form of a developed meander. In the plain, the main factor affecting the river meandering is the alluvial formation, the slope is low and the meanders are inscribed and plain, whereas in the mountainous part the river changes are subject to valley changes and the meandering state is seen throughout the valley.

The results of lateral conduit changes also showed that the average migration rate of the Givi Chay duct during the 19-year interval was about 0.87 m/year. It should also be noted that, during the period 2000 to 2019, approximately 39.52 hectares were generally added to the right bank of the river and 11.62 hectares decreased to the right bank.

In general, changes in the Givi Chay River Plans have been attributed to the expansion of existing meanders, displacement of the river path, and increased curvature and formation

of small meanders. Hydrological processes are caused by the process of supply of sediment and sediment discharge, dam construction and lithological resistance of the riverbed as well as human interference such as, encroachment of the riverbed, construction of bridges, sand harvesting**.**

Keywords: Morphological Characteristics, Lateral Displacement, Transect Method, Migration Rate, Givi Chay

References: (In Persian)

Asghari-Saraskanroud, S., Zeinali, B., & Asghari-Saraskanroud, S. (2016). بررسی نحوه توزیع قدرت رودخانه و تنش برشی و اثرات مخاطره‌آمیز آن در محدوده شهری سراسکنرودچای [Evaluation of river power distribution, shear stress and their hazard effects on the urban range of Saraskand Chay River]. *Geographical Researches*, *31*(1), 46-58.

Esfandiary Darabad, F., Rahimi, M., & Rahimi, M. (2017). تحلیل میزان مهاجرت عرضی مجرای رودخانه ارس با استفاده از روش ترانسکت در طی سال های ۲۰۱٦-۱۹۸۷ (از سد خدا آفرین تا سد میل مغان) [Analysis of lateral migration rate of Aras River using Transect method from 1987-2016 years (from khoda Afarin dam to Mil Moghan dam]. *Quantitative Geomorphological* Researches, *5*(4), 41-58.

Esfandiary Darabad, F., Rahimi, M., Lofty, K., & Ebadi, E. (2020). آشکارسازی تغییرات جانبی مجرای رودخانه قزل اوزن در بازه زمانی ۱۹۹۳ تا ۲۰۱۳ [Lateral change detection of Ghezlozan River Channel from 1993 to 2013]. *Researches in Geographical Sciences*, *20*(57), 113-124.

Fatemi Aghda, S. M., Fayazi, F. A., & Alipour, D. (2003). بررسی زمین‌شناسی مهندسی بخشی از رودخانه‌ی کرخه (روستای عبدالخان تا روستای الهایی) [Investigation on the engineering geology part of Karkheh from Abdol-Khan to Elhai Village]. *Quarterly Journal of Science Kharazmi University*, *18*(53), 163-179.

Kheirizadeh, M., Rezaei Moghadam, M., Rajabi, M., & Daneshfaraz, R. (2017). تحلیل تغییرات جانبی مجرای رودخانه زرینه‌رود با استفاده از روش‌های ژئومورفولوژیکی [Analyzing lateral changes of the Zarrineh-Roud River Channel using Geomorphometric Techniques]. *Quantitative Geomorphological Researches*, *5*(4), 76-102.

Khoshraftar, R., Ahmadi, A., Fayzolah-poor, M., & Hamedi, N. (2019). بررسی پیچان‌رودهای قزل اوزن در محدوده‌ی شهرستان ماهنشان- زنجان [A study of Gezel Ozan River meanders in Mahneshan County-Zanjan province]. *Quantitative Geomorphological Researches*, *7*(4), 15-30.

Maghsoudi, M., Sharafi, S., & Maghami, Y. (2010). آباد با خرم رودخانهٔ مورفولوژیکی الگوی تغییرات روند از استفاده GIS، RS و Auto Cad [Change detection of Khoram abad river morphological pattern with RS, GIS and AUTO CAD]. *Spatial Planning (Modares Human Sciences)*, *14*(3), 275-294.

Rahimi, M., Hejazi, A., Modiri, M., & Mehrvarz, A. (2017). بررسی تغییرات رودخانه ارس با استفاده از روش ترانسکت در طی بازه زمانی ۱۹۸۷ تا ۲۰۱٤ و تأثیر سازه‌های احداثی در اصلاح مسیر رودخانه (از اصلاندوز تا پارس‌آباد) [Investigation of channel change of Aras River by using transect method from 1987 to 2014 and the effects of built structures on the modification of river route (Case study: From Aslandoz to Parsabad)]. *Journal of Geography and Environmental Hazards*, *20*(5), 73–89.

Rezaee Moghadam, M. H., Kheirizadeh, M., & Rahimi, M. (2016). بررسی جابه جایی جانبی مجرای رودخانه‌ی ارس از سال ۱۳۷۹ تا ۱۳۹۳ (از ۱۵ کیلومتری غرب شهر اصلاندوز تا خروج رودخانه از محدوده‌ی سیاسی ایران) [Investigating the lateral movement of Aras River from 2000-2014 (15 km away from west of Aslanduz City to exit of the river in Iran's border)]. *Geography and Environmental Planning*, *7*(3), 15 – 32.

Rezaee Moghadam, M. H., Rahimi, M., Nikjoo, M. R., & Yasi, M. (2017). تحلیل ژئومورفولوژیکی مجرای رودخانه قره‌سو با استفاده از مدل رزگن (پایین‌دست سد سبلان) [Geomorphological analysis of Gara Sou River Channel using Hierarchical Rosgen Model (From Sabalan Dam to confluence of Ahar-Chay River)]. *Quantitative Geomorphological Researches*, *6*(2), 1 – 14.

Rezaee Moghadam, M. H., Sarvati, M. R., & Asghari Sareskanrood, S. (2012). بررسی تغییرات شکل هندسی رودخانه قزل اوزن با تأکید بر عوامل ژئومورفولوژیک و زمین‌شناسی [Studying of role of geological and geomorphologic factors on the geometry of river of Gezel Ozan]. *Geography and Environmental Planning*, *23*(20), 1-14.

Soltani-Gerdefaramarzi, S., Asgari Varzideh, S., & Tazeh, M. (2018). بررسی تغییرات زاویه مرکزی و شعاع مرکزی در مئاندرهای رودخانه گاماسیاب با استفاده از سنجش از دور و سیستم اطلاعات جغرافیایی [Investigation of change trend of the central angel and radius in the meanders of Gamasiab River using RS and GIS]. *Journal of Geography and Planning*, *22*(63), 225 – 240.

References: (In English)

Aswath, M.V., & Satheesh, V.R. (2008). Factors Influencing the Sinuosity of Pannagon. River Kottayam, Kerala, India: An assessment using remote and GIS. *Environmental Monitoring and Assessment*, *138*(1-3), 173-180.

Atwwod, J., Watts, T., Price, K., & Kastens, J. (2005). The big picture-satellite remote sensing application in rangeland assessment and crop insurance. Reviewed and Published Proceedings. Agricultural Outlook Forum 2005. Lawrence: The University of Kansas.

Bag, R., Mondal, I., & Bandyopadhyay, J. (2019). Assessing the oscillation of channel geometry and meander migration cardinality of Bhagirathi River, West Bengal, India. *Journal of Geographical Sciences*, *29*(4), 613-634.

Batalla, R. J., Iroume, A., Hernandez, M., Llena, M., & Vericat, D. (2018). Recent geomorphological evolution of a natural river channel in a Mediterranean Chilean basin. *Geomorphology*, *303*, 322-337.

Chaiwongsaen, N., Nimnate, P., Choowong, M. (2019). Morphological changes of the lower Ping and Chao Phraya Rivers, North and Central Thailand: Flood and coastal equilibrium analyses. *Open Geosciences*, *11*(1), 152–171.

Clarke, K. D., Pratt, T. C., Randall, R. G., Scruton, D. A., & Smokorowski, K. E. (2008). Validation of the flow management pathway: Effects of altered flow on fish habitat and fishes downstream from a Hydropower Dam, Northwest Atlantic Fisheries Center Science, Oceans and Environment Branch Fisheries and Oceans Canada St. John's, NL. *Canadian Technical Report of Fisheries and Aquatic Sciences*, *2784*, 1-119.

Dewan, A., Corner, R., Saleem, A., Rahman, M. M., Haider, M. R., Rahman, M. M., Sarker, M. H. (2017). Assessing channel changes of the Ganges-Padma River system in Bangladesh using Landsat and hydrological data. *Geomorphology*, *276*, 257-279.

Feyisa, G., Meilby, H., Fensholt, R., & Proud, S. (2014). Automated water extraction index: a new technigue for surface water mapping using Landsat imagery. *Remote Sensing of Environment, 140*, 23-35.

Giardino, J. R., & Lee, A. A. (2011). Rates of channel migration on the Brazos River, Submitted to the Texas Water Development Board, Department of Geology & Geophysics, *Texas A & M University*, Final report contact no. 0904830898.

Kibet Langat, F., Kumar, L., & Koech, R. (2019). Monitoring river channel dynamics using remote sensing and GIS techniques. *Geomorphology, 325*, 92-102.

Magdaleno, F., Yuste, J., & Fernandez. A. (2011). Meander dynamics in a changing river corridor, *Geomorphology, 130*, 197-207.

Matyas, M.L.A. (2015). Methods of analysis the riverbed evolution. A case study of two tributaries of the upper Vistula River. *Infrastruktura I Ekologia Terenów Wiejskichin frastructure And Ecology of Rural Areas, 1,* 1313-1327.

Mcfeeters, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. *International Journal of Remote Sensing*, *17*(7), 1425-1432.

Minh Hai, D., Umeda, Sh., & Yuhi, M. (2019). Morphological changes of the lower Tedori River, Japan, over 50 years. *Water, 11*, 1852, 2-17.

Oorschot, M. V., Kleinhans, M., Buijse, T., Geerling, G., & Middelkoop, H. (2018). Combined effects of climate change and dam construction on riverine ecosystems. *Ecological Engineering*, 120, 329–344.

Rinaldi, M., & Simon, A. (1988). Bed-level adjustments in the Arno River, central Italy. *Geomorphology*, *22*(1), 57–71.

Shen, L., & Li, C. (2010). Water body extraction from Lansat ETM+ Imagery using Adaboost Algorithm. Paper presented at *18th International Conference on Geoinformatics. China*.

Shields, F., Douglas, S., Andrew, S., & Lyle, J. (2000). Reservoir effects on downstream river channel migration. *Environmental Conservation*, 27(1), 54–66.

Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery, *International Journal of Remote Sensing*, *27*(14), 3025-3033.