

# Analyze Fluctuations in The Water Level of Erai River using Sentinel Data

Yukta Chikate

Department of Computer Technology,  
Yeshwantrao Chavan College of Engineering,  
Nagpur, India

Atharva Konge

Department of Computer Technology,  
Yeshwantrao Chavan College of Engineering,  
Nagpur, India

**Abstract**—Water has been one of the essential resources for humankind, and it is vital for our survival. The current study analyzes the water level changes in the Erai reservoir using geospatial analysis and identifies the factors contributing to the fluctuations in water level. The water from the Erai River is supplied to Chandrapur district. Here, we have used Sentinel data to analyze the RGB and NDWI bands, with the Erai reservoir being the area of interest. The data used from the Sentinel over the period May 2019 – Feb 2021 is used to get the Erai water body area at different time intervals and compare it with the area of nominal boundary to determine the changes in water level. The nominal boundary is compared to the boundary obtained from Bluedot water observatory API to check the accuracy. By monitoring the water level, it is observed that the water level of the Erai reservoir from (April-September) 2019 increases, and after that, there is a decrease from (October-April) 2020 and the same pattern is observed till 2021. Further, we analyze the factors responsible for the fluctuations in water level.

**Keywords**—Sentinel, water level, erai river, eo-learn, python, water management

## I. INTRODUCTION

The water level of a water body such as a river, lake, etc., is the height of water above the ground. The water body level is used to determine whether the water body is shallow or deep [1]. Moreover, if we consider that a water body area will remain almost fixed, we can determine how much water the water body can have; this would help us plan our projects such as water distribution, hydroelectric plants, etc., more efficiently. Changes in water level can have a profound impact on the nearby areas of a water body. If there is a decrease in water levels, the amount of water available for distribution may decline [8]. On the other hand, an increase in water level can lead to water bodies spread over a larger area [2]. In addition to the problem of water distribution and flooding concerns, changes in water level can also impact the aquatic flora and fauna, thus disturbing the ecosystem. Earlier studies have indicated that water level fluctuations significantly affect the aquatic flora and fauna, especially the water body's licorice region.

The Erai River is the major tributary of the Wardha River in Chandrapur District. The total length of the Erai River from the origin near the Tadoba tiger reserve to Wardha River's meeting point is 45 km approx. [3]. In peak summer, most of the time, the Erai River's water level falls drastically down due to many factors such as high temperatures of the Chandrapur district, industrial consumption, domestic use, etc. The paper aims to determine the water level of the Erai River and

analyze the variations in water level over time. By monitoring the water level changes, we studied various factors related to Erai River's changing water level. Further, we can take proper decisions and preventive measures to handle the ill effects.

To find the water level, we first saw the nominal boundary of the water body. To check the accuracy, we compared it from the blue dot water observatory, which provides an API from where we can get the boundary of around 40000 water bodies. To detect water level changes, we are using data from Sentinel Hub, which is an API that provides satellite data. Satellite imagery was used to get the RGB and NDWI bands, the RGB band was used to find the actual image of the water body, and the NDWI band was used to see the difference between land and water body. We use B2, B3, and B4 bands for RGB visualization; these bands can be obtained by passing TRUE-COLOR-S2-L1C, which is the RGB layer's name in the Sentinel Hub configurator. For NDWI (Normalized difference water index) calculation, we use B3 and B8 bands. To handle the data from the Sentinel hub efficiently, we used Eo-learn. Eo-learn is a module that simplifies the task of extracting information from satellite imagery. Usually, while using Eo-learn, we define a workflow consisting of a sequence of operations performed on satellite imagery to get relevant data. A workflow may include steps such as downloading satellite data, applying cloud detection, using NDWI Feature extraction, applying NDWI thresholding, and some more appropriate steps to get the final data [4][6].

By monitoring the water level, it is observed that the water level of the Erai reservoir from April 2019 to September 2019 increases, and after that, there is a decrease from October 2019 to April 2020. [7] We see the same increasing trend from April 2020 to September 2020 and a fall in water level from October 2020 to February 2021. It has been observing when there is a sudden decrease of the water level in the graph, and it is due to the cloud obstructing the satellite's view. Other factors were analyzed from the reference papers, such as temperature, soil moisture, precipitation, which may lead to changes in the Erai reservoir level.

## II. METHODOLOGY

### A. Process Flow

We create an account on the sentinel hub and authenticate it to get a unique instance identity to extract the data. The id further helps in fetching the data from the sentinel hub. So we can use the instance id as a reference key.

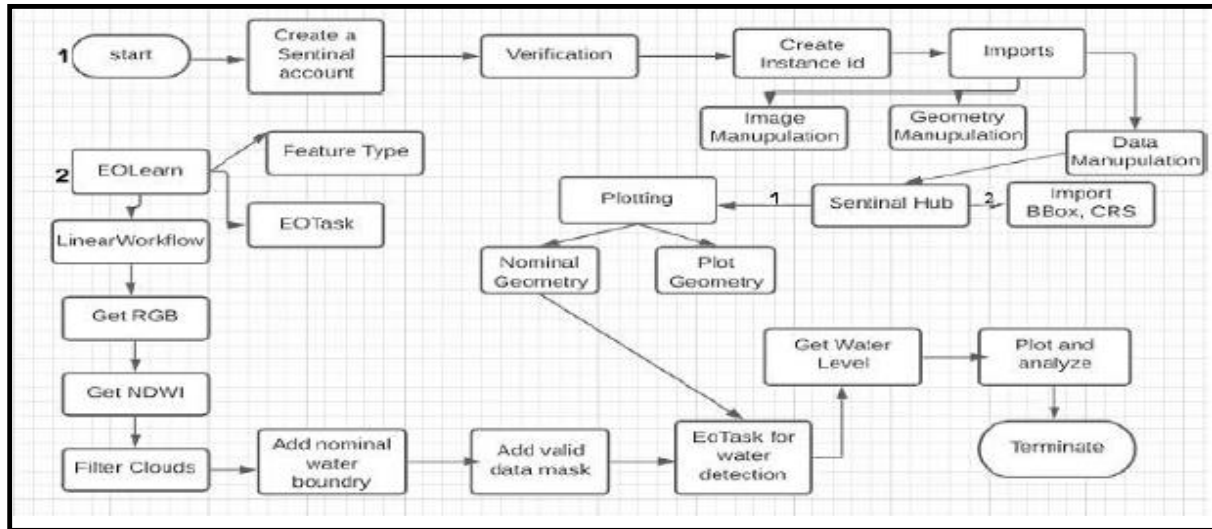


Fig.1. Process Flow chart

From fig.1, gathered all the necessary imports which are used during server-client interaction. Request import use in demanding data from the server whenever data is in JSON format—numpy used in data manipulation, pandas used in geometry or shapely manipulation. Eo-learn makes the extraction of valuable information from satellite imagery easy. Every water body has a unique id. We define a water body identity on which the analysis is going to perform. We created a module that sends the request to the server to access the data of the selected water body. The server sends the right, and the data is gathered in a variable. We get the data of the nominal geometry. Now we need to plot the data by using a plot geometry function. The plot geometry function helps to display a geometrical boundary of the reservoir. Now, whenever we use sentinel hub data, we need a bounding box. The sentinel hub provides an object name Bbox as a bounding box. Bbox is nothing but a buffer created around the nominal boundary, which can be seen in the blue color and the orange color outline is the reservoir's boundary, i.e., fig.3.

After the setup of the data is done, we can now apply the Eo-learn module. When we define Eo-learn, we define a workflow that is nothing but a set of operations applied one by one on the images. In the group of operations, we first need an RGB band that can be used to see the water body's actual colors. Then we need the NDWI band that helps in converting the image so that it detects the refracted values of the water and the land. This helps in clear differentiation in the detection of the boundary of the water body. We use B3, and B8 bands in the analysis where B3 is the green color band and B8 is the linear infrared sentinel band. So the equation form to get an NDWI value is

$$NDWI = \frac{B3 - B8}{B3 + B8}$$

Where B3 is the green color band, and B8 is the near-infrared sentinel two bands. These NDWI values are used in detecting the water level through satellite images. The function uses a module that helps to measure water extend area by self-geometry area. Along with that, it also returns water level, status, geometry return.

To calculate water level, we require a variable named measured water extend, which can be received from a module, and water status is obtained from the S2 function. We also use some custom task functions in the workflow as valid data predicate, which returns valuable data as a union of pixels. Add value data coverage is used to plot all the valuable data in our class.

Now we initialize the EoTask in which we define all the steps of the flowchart of EoLearn. The first is to download the RGB layer, "TRUE-COLOR-S2-L1C," in the sentinel hub configuration. The second set is to download the NDWI layer. The satellite images fetched from the sentinel hub contain many distractions. Some of them are clouds, so to get a clear image, we use cloud detection to filter the clouds from the images. Then we apply a raster layer to show nominal water extend. Then as defined in the workflow, we import a valid data mask and data average. And initial the task to detect water level by the class of water level detection. Lastly, we can define the entire workflow and then get the dependency graph. We also need to determine the time interval and the bounding box in the workflow, and then it is ready to execute. The result of NDWI images can be displayed in Eo-Patch. All the 12 filtered images and the water body's outline boundary can be viewed in fig.4. Then we see the true color images in fig.5, on which we apply two lines. The white line in the image is the nominal boundary, and the green color line is the actual boundary. From this, we can differentiate between them. Using this logic, we study the water level detection by dividing the current water body area by the nominal water body area. The output we get is the water level expected

relative to the nominal water level. The output data is then plotted with respect to time in the graph for further analysis. The value is around 1, which is (nominal water area). The graph contains some outliers, which is due to the cloud coverage.

### III. RESULTS AND DISCUSSIONS

#### A. Plotting

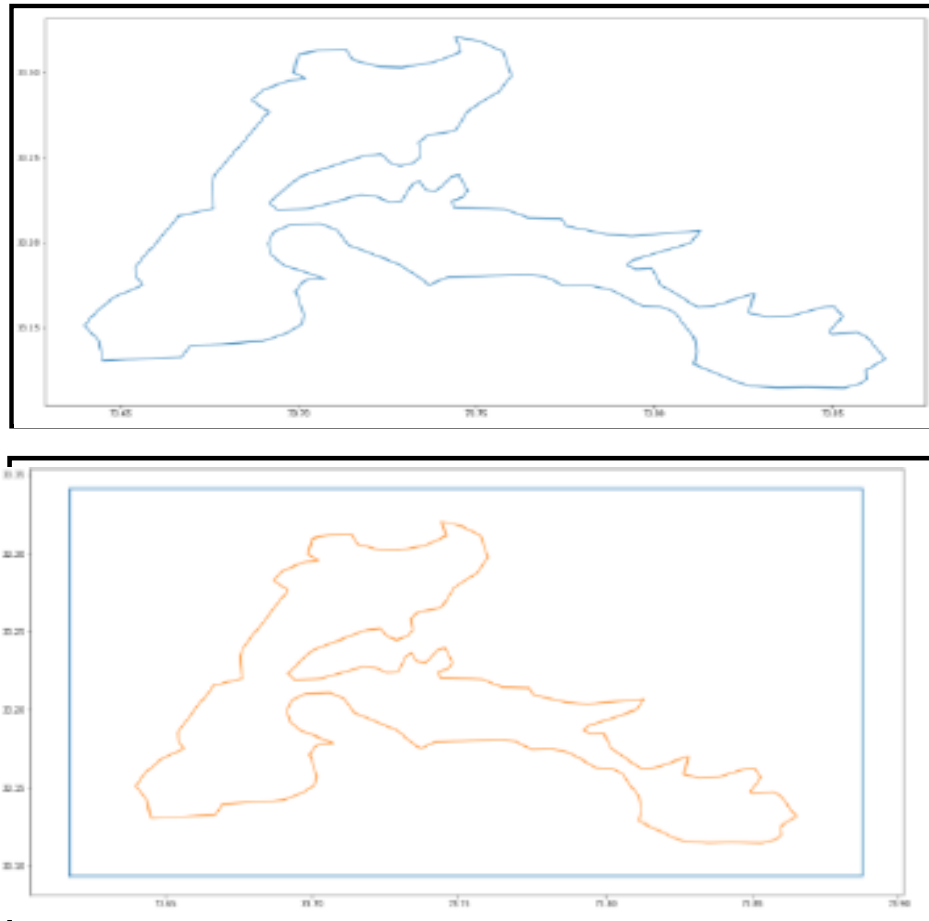


Fig.3. Bounding box added to the nominal boundary

From fig.2 shows a plot of a nominal boundary of the reservoir for a particular period which is May 2019 to Feb 2021 that is to be analyzed. For the accurate boundary of the Erai River, it is compared to the shapefile from BlueDot Water Observatory API.

And fig.3. shows to plot the Sentinel Hub data, we require a bounding box (represented by the blue rectangle) denoted as BBox is added to the nominal boundary (defined by the orange line) specific buffer.

B. Result

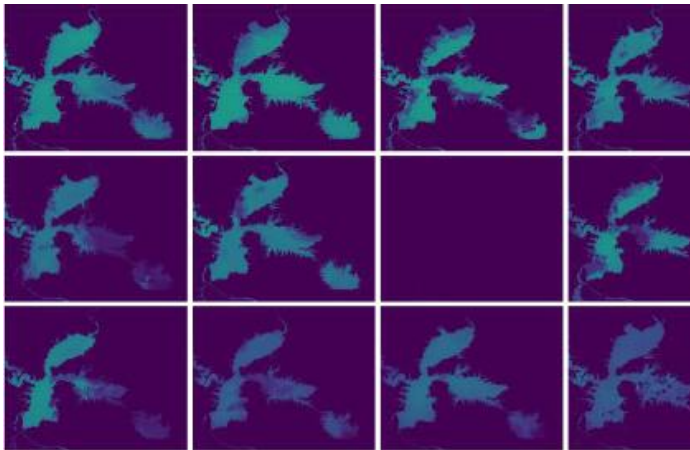


Fig.4. NDWI image of Errai River

Fig.4 represents the NDWI image of Errai River, taken at different time intervals. NDWI helps in specifying the water boundary outlines more clearly. Here the reflective part of the land and water is differentiated by the index color value, so we can easily distinguish between water area and land area. The blurry parts of the image are due to the cloud coverage interference. It can be observed that whenever cloud coverage increases, the river's image is not that clear.

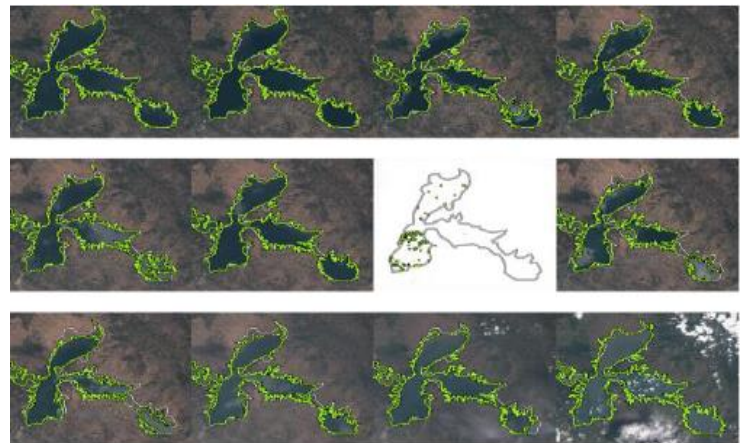


Fig.5. RGB image of Errai River

Fig.5. represents RGB image of Errai River, along with that the nominal boundary of the river is depicted by white color and the current boundary of the river is shown in neon green. It helps in comparing the distance between the nominal boundary and the present boundary. The considered study area is observed about the current boundary as the images are taken at different time intervals for further analysis.

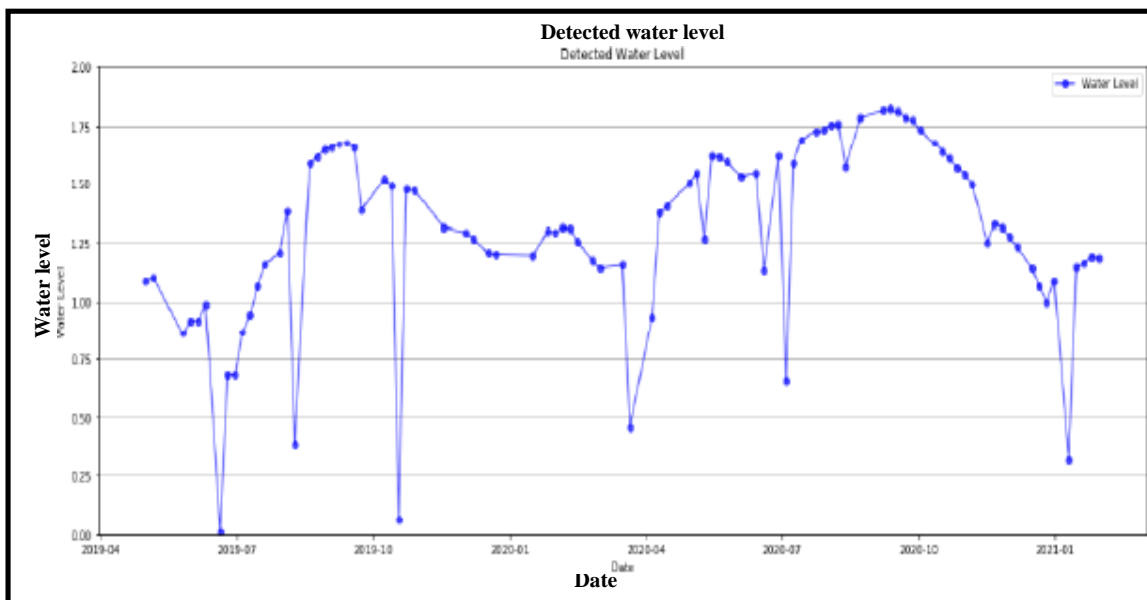


Fig.6. Line Plot of water level with respect to time

### C. Discussion

Figure 5 represents a line plot of the water level of the Erai reservoir concerning time. Here, we can observe the changes in the water level of the Erai Reservoir with respect to the period [5]. The analysis was performed over two years, from May 2019 to February 2021. From the line plot study, we understand that the water level rose from April 2019 to September 2019. The local maxima in this increasing slope were found in September 2019. After that, we noticed a decrease in the water level till April 2020.

Further, it was observed that the water level increased again in May 2020 up to September 2020. The water level also decreased from September 2020 to February 2021. During the entire period, it was observed that the global maxima were around September 2020.

From the graph, when there is a sudden sharp decline in water level, it is due to the clouds that obstruct the satellite's view, due to which the calculated area of the Erai Reservoir is found to be less than what it is. And this impacts the data of the water level. Therefore, from the graph, we see that when the cloud coverage increases, there is a sudden fall in the water level.

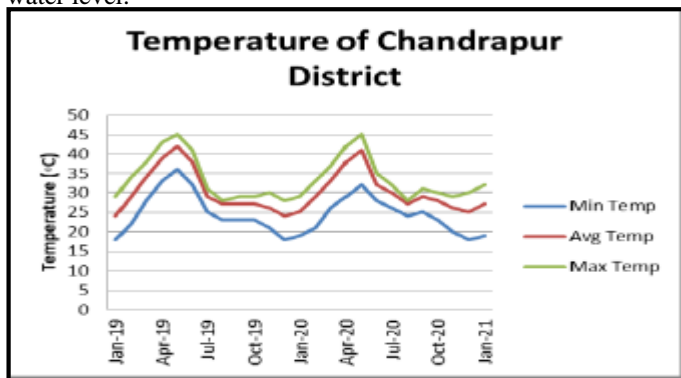


Fig.7. The temperature of Chandrapur district of years 2019 and 2020

Temperature is one of the factors which can contribute to changes in water level. A greater temperature leads to more evaporation of water, which in the long run can cause significant changes in water level. Chandrapur is one of India's hottest districts, where the temperature goes to above 40 degrees Celsius in the summers. From Figure 7, it can be observed that in March to May, the temperature increases significantly; also, from the water level plot, we see that these are the months where the water level goes to the lowest.

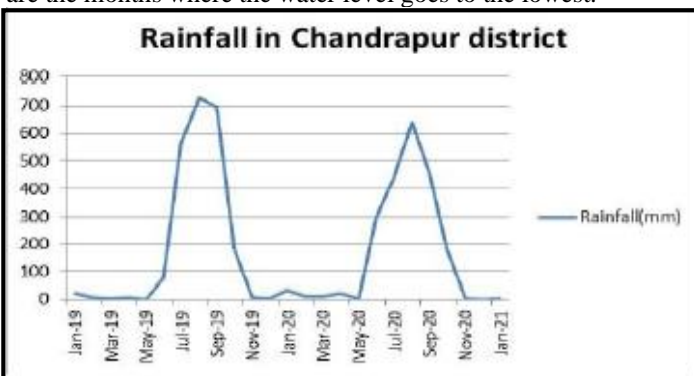


Fig.8. Rainfall in Chandrapur District of year 2019-2020

Another important factor that would affect water level is rainfall. If a region receives rainfall, the water bodies' water level in that region would likely show an increase. From the graph of rainfall in Chandrapur district, it can be observed that the amount of rain increases from June to August or September, and after that, it starts decreasing. A similar trend can be seen in the water level of the Erai reservoir, where the water level showed an increase till August, and after that, the water level started decreasing.

### IV. CONCLUSION AND FUTURE SCOPE

The This model's need is to analyze the water level changes in the Erai reservoir using geospatial analysis and identify the factors contributing to the fluctuations in water level. First, we plot the nominal boundary to get the relative area of the water body and create a bounding box to specify the location for which we request the satellite data. Then, we have monitored the water level by sentinel hub and observed that the water level of the Erai reservoir from April 2019 to September 2019 increases, and after that, there is a decrease from October 2019 to April 2020. We see the same increasing trend from April 2020 to September 2020 and a fall in water level from October 2020 to February 2021. We observed the water level fluctuations by using the RGB and NDWI bands, RGB band was used to find the real image of the water body, and the NDWI band was used to find the water level of the water body. The project's main objective was to observe and study the changes in the water level of the Erai River as per seasons so that we can solve the water management problem of any Chandrapur region. This study also analyzed various factors that may affect the water level, which includes temperature, rainfall. This method could be helpful in flood management of multiple regions.

### V. REFERENCES

- [1] Cantonati, M.; Poikane, S.; Pringle, C.M.; Stevens, L.E.; Turak, E.; Heino, J.; Richardson, J.S.; Bolpagni, R.; Borroni, A.; Cid, N.; Čtvrtlíková, M.; Galassi, D.M.P.; Hájek, M.; Hawes, I.; Levkov, Z.; Naselli-Flores, L.; Saber, A.A.; Cicco, M.D.; Fiasca, B.; Hamilton, P.B.; Kubečka, J.; Segadelli, S.; Znachor, P. Characteristics, Main Impacts, and Stewardship of Natural and Artificial Freshwater Environments: Consequences for Biodiversity Conservation. *Water* 2020, 12, 260.
- [2] Talbot, C.J., Bennett, E.M., Cassell, K. et al. The impact of flooding on aquatic ecosystem services. *Biogeochemistry* 141, 439–461 (2018). <https://doi.org/10.1007/s10533-018-0449-7>
- [3] [https://www.mpcb.gov.in/sites/default/files/focus-area-reports-documents//Erai\\_%26\\_Zarpat\\_River\\_Action\\_Plan-Revised.pdf](https://www.mpcb.gov.in/sites/default/files/focus-area-reports-documents//Erai_%26_Zarpat_River_Action_Plan-Revised.pdf)
- [4] Li, Yuanzheng & Gong, Xiaoqiang & Guo, Zhen & Xu, Kaipeng & Hu, Dan & Zhou, Hongxuan. (2016). An index and approach for water extraction using Landsat–OLI data. *International Journal of Remote Sensing*. 37. 3611–3635. 10.1080/01431161.2016.1201228.
- [5] Poan, E.D., Gachon, P., Dueymes, G. et al. West African monsoon intraseasonal activity and its daily precipitation indices in regional climate models: diagnostics and challenges. *Clim Dyn* 47, 3113–3140 (2016). <https://doi.org/10.1007/s00382-016-3016-8>
- [6] Martin Claverie, Junchang Ju, Jeffrey G. Masek, Jennifer L. Dungan, Eric F. Vermote, Jean-Claude Roger, Sergii V. Skakun, Christopher Justice, The Harmonized Landsat and Sentinel-2 surface reflectance data set, *Remote Sensing of Environment*, Volume 219, 2018, Pages 145–161, ISSN 0034-4257.
- [7] Frantz, D. FORCE—Landsat + Sentinel-2 Analysis Ready Data and Beyond. *Remote Sens.* 2019, 11, 1124.
- [8] Wang Z, Wang T, Liu X, Hu S, Ma L, Sun X. Water Level Decline in a Reservoir: Implications for Water Quality Variation and Pollution Source Identification. *Int J Environ Res Public Health*. 2020;17(7):2400. Published 2020 Apr 1. doi:10.3390/ijerph17072400