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Amu River Coastal Degradation Assessment Using Remote Sensing And GIS

[1]Naqiburahman Rahmani, [2]Safi Pamir jan, [3]Abdurahman Hadafmand, [4]Hejratullah Hejran,

[1]Remote Sensing and GIS Specialist, [2,3,4]Integrated Water Resources Management Specialist,
[1] National Institute of Technology Warangal, Tarángana DOI: 0000-0002-6407-8865
[1,2,3,4]Ministry of Water and Energy, Afghanistan

Abstract

Land degradation is a pervasive problem in many parts of the world, and success in fighting against degraded land requires a better understanding of the causes, effects, weather, soil, land cover, and socio-economic factors. The current research uses advanced remote sensing technology and GIS to determine the quantity of endangered and destroyed land from remote sensing information at any time, providing accurate and reliable information. This article examines the water damage of the Amu Sea coast using remote sensing and GIS methods, which are Land Use Land Cover, Slope, and NDWI (the difference in land surface cover in the period of 2000-2022 with analysis based on image data) Landsat 7 and Landsat OLI 8 satellites used the supervised maximum classification method. The result shows the total amount of degraded area is 297.077207 KM2 and the area under threat is 959.0996728 KM2 the most degraded District is Shurtipa in the Balkh province 83.185498 KM2 and the most under threat District is Imam Sahib in Kunduz Province 163.930124 KM2.

KEYWORDS: RS, GIS, Amu River Basin, NDWI, LULC

1. Introduction

The construction of control buildings has been recorded in the history of very old civilizations. The Chinese built flood control buildings on the sea coast (yellow) 2500 years ago, and from here it can be said that the construction of these buildings was implemented under the supervision of the Shahi Han family, but probably the first flood control buildings. It was done on both sides of the Nile during the reign of King Eminhat of Egypt due to flood waters (Fao, 2008).

Erosion of sea coasts has short-term and long-term effects on people's way of life and the short-term economic-social effect causes the immediate loss of people's capital, such as the loss of residential houses, agricultural lands, agricultural products, and the loss of people's jobs. And its long-term effects are direct and indirect and its direct effects, include creating problems for sending children to schools, and its indirect effects are creating problems for the health of children and their mothers (Fao, 2008: Zhao et al., 2018).

The regulation of the seas and flood control has changed the state of erosion of the seashores in general. The erosion of the seashores and human-related activities have a necessary effect on the economy of a nation. Consolidation of the seashore is an important part of the regulation of the sea, an important issue of the design of the constructions of the coastal consolidation. The construction of the buildings is to guide the water to a favorable level and reduce the damages caused by most of the accidents. The purpose of the construction of these types of buildings is to prevent the erosion of the coasts and create stability of the sea coasts (Yuksel et al., 2008).

Erosion of sea shores harms human life, and on the contrary, human activity has an impact on sea erosion. Destruction of sea shores and canals occurs as a result of physical forces and the biological environment individually or in a combined form, which includes infiltration, increasing shear forces, and the absence of rear supports for external waters. The high price of water level reduction compared to soil permeability is the location and depth of tensile seams, and the existence, and location of trees (Maqsoom et al., 2020; U.S. Army Corps of Engineers, 2014).

As mentioned before, the factors of the destruction of sea coasts are operations or incidents that result in mechanisms of destruction of sea coasts. destruction of sea coasts may have a cause, but mostly in the process of destruction of sea coasts. at the same time, several factors play a role to prevent the washing of sea shores, first of all, the factor of washing the beaches should be identified, and some of these factors are described below (Boakye et al., 2020; U.S. Army Corps of Engineers, 2014).

2. MATERIAL AND METHODOLOGY

2.1. Study area

The study area is located in the northern region of Afghanistan, which covers Badakhshan Takhar, Kunduz, Balkh, Jawzjan, Baghlan, and Bamyan provinces and 1177.96 km have a Water border along with Tajikistan, Uzbekistan, and Turkmenistan (Figure 1). The study area covers approximately 9597260 ha of land with an elevation of 231 Qrqeen to 6947 m Wakhan and slopes of 0 to 80 %. The land use/cover of the area contains agriculture, forest, glaciers, rangeland, bare rock, water bodies, and residential areas. Average annual precipitation and temperature are 388.9 mm and 16.2 °C, respectively (MoWE).The highly erosive storms occur during the Summer and spring seasons.

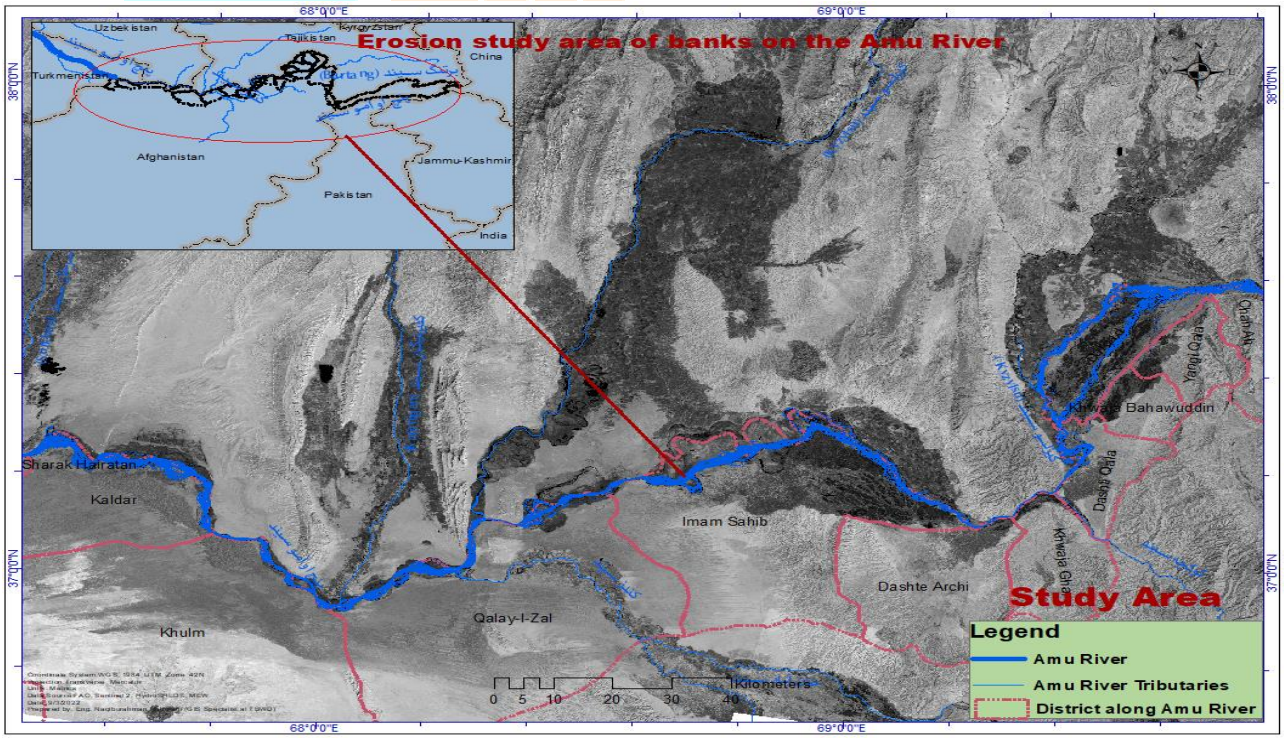


Figure.1 Study area Amu River basin by author.

2.2 Factors of washing and destroying the coasts of the Amu River

A side construction on the banks of the river from Tajikistan and Uzbekistan. the main reason for the destruction of the banks of the Amu River towards Afghanistan is the unilateral reconstruction of the countries of Tajikistan and Uzbekistan. That these facilities have caused the water flow of the Amu River to change towards Afghanistan, which is a violation of international laws in the area of transboundary waters (Kiruthika et al., 2017; Wiedmann et al., 2020).

Among other factors, the movements of the military ships of the country of Uzbekistan have a direct role in the destruction of the banks of the Amu River, which causes the water waves to flow toward Afghanistan (Wiedmann et al., 2020). The natural flow of the river towards Afghanistan.

The presence of mountains in the north of the Amu River causes the strengthening of the banks of the river, which increases the speed of the river in the downstream part, and the softness of the soil in the downstream part of the river causes more erosion of the banks of the river (Premalal et al., 2001; Wiedmann et al., 2020).

The presence of forests in the northern parts of the Amu River, the density of this part, and the cutting of forests in the southern parts have caused it to lose its position against the water, and is easily degraded. Removing gravel from the banks of the river during the period of water scarcity in different areas of the Qarqin and Khamab districts.

Ignoring river boundaries: A river bank is defined as the area of width and margin that is maintained by normal flow or flood within a return period of 25 years and any encroachment on this area, or residential development. Including expansion of agricultural land is not allowed (Wiedmann et al., 2020).

The presence of curves and bends along the river: Irregularities in the length of the river and the velocity of the water in the downstream part of the river. These two mentioned factors cause the irregularity of the speed of the river horizontally and vertically, near any coast, where the current speed is high, the same coast will be washed more than the opposite coast. The curve changes and creates the conditions for the creation of centrifugal forces and the transverse flow of water. The soil washed from the concave shore settles on the next convex part of the same slope. The depth remains constant or the water depth decreases as a result of the sedimentation of transported material. Concentric forces and transverse circulation both accelerate beach erosion, resulting in meandering or meandering currents in the ocean's path and causing beach erosion (Wiedmann et al., 2020).

Maximum water flows: As a result of the assessment of river bank erosion factors, it was found that high water flow plays an important role in river bank erosion. The Amu River is also a barrier to these flows and whenever this flow exceeds the average (5-12) percent, 90% of the erosion occurs during this variable flow when the river does not pass through these flows. In this case, even if it is for a short period, the level of destruction on the banks of the river will be high (Wiedmann et al., 2020).

Effects of groundwater on river erosion: Under certain geological and morphological conditions, groundwater can play an important role in river erosion. For example, if a river bank is located in a watershed and the water level fluctuates greatly during the seasons, in this case when the water level in the river is low the groundwater will flow to the river which destroys soil to the river and this causes the river to widen and erode over time (Wiedmann et al., 2020).

Moisture in the banks of the river: As a result of a study on the Hook River in England in 1979, it was found that the moisture present in the washing of the river banks plays an important role.

Soil type on river banks, It should not be overlooked that the type of soil along river banks plays an important role in beach erosion. Some types of soil have a good water resistance, that is, the internal structure of the soil has a good resistance when interacting with water, but unlike other types of soil, as soon as the water reaches the internal structure of the soil, it is destroyed. and the adhesion between these soil particles is very low. Here, a detailed discussion of the soil types along the Amu River from Badakhshan's Wakhan District to Qarqin, Jawzjan was arranged and summarized with the help of GIS (Zhou et al., 2020).

Fig.2 Amu River Basin Coast degradation photo by author.

3. METHODOLOGY Data Collection

Data Collection
Slope Analysis
Soil Mapping
NDWI Analysis
Land Use Land Cover Assessment
Assessment of Soil Erosion

No	Type of Data	Data Description	Name of the Service that Provide the Data
1	DEM	SRTM DEM (30 Resolution)	USGS
2	Soil Data	FAO Digital soil Map of the World	Food and Agriculture Organization
3	Satellite Data	Landsat 5 and Landsat 9	USGS
4	LULC	Sentinel 2 10 Resolution	Sentinel 2 Land use land Cover

Table.1 Data source by author.

4. Analysis and Discussion

Preparation of DEM, slope map, and aspect map;
The aspect identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors. It can be thought of as the slope direction. The values of each cell in the output raster indicate the compass direction that the surface faces at that location.

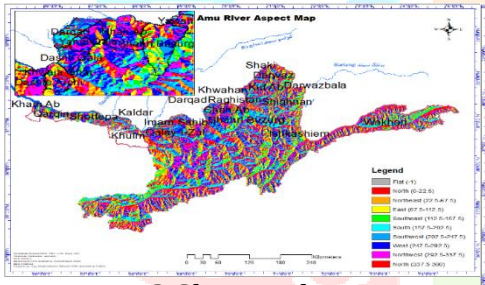


Figure.3 Slope analysis map

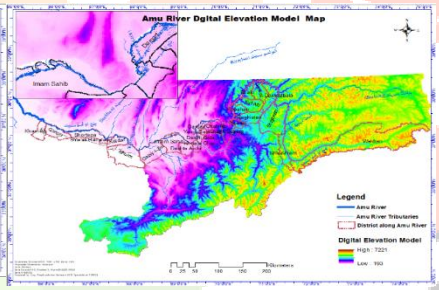


figure.4 Digital elevation model

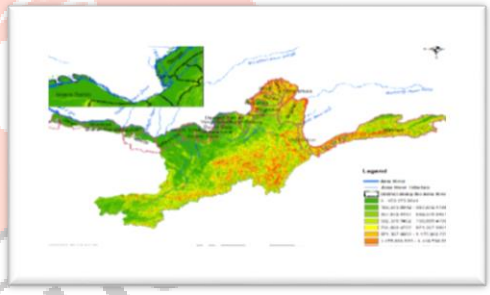


figure.5 Slope Percentage

The slope represents the rate of change of elevation for each digital elevation model (DEM) pixel, measured in degrees. The slope represents the steepness of the surface and is symbolized into three classes that are shown using color saturation (brightness). To create a slope map of the Amu River basin, and a spot-height point in the map that determined the Amu River flow forward Afghanistan side and its potential with the corresponding issue.

5. Soil Mapping and analysis

The study area which is located in the northern region of Afghanistan, that covers approximately 9597260 ha of land which have three type of soil the figure (Figure 5.1) represents the area of the different type of soil which we can understand the impact of water by those type of soil, and the area with an elevation of 231 Qrqeen to 6947 m Wakhan. The land use/cover of the area contains agriculture, forest, glaciers, rangeland, bare rock, water bodies, and residential areas. Average annual precipitation and temperature are 388.9 mm and 16.2 °C, respectively (MoWE).

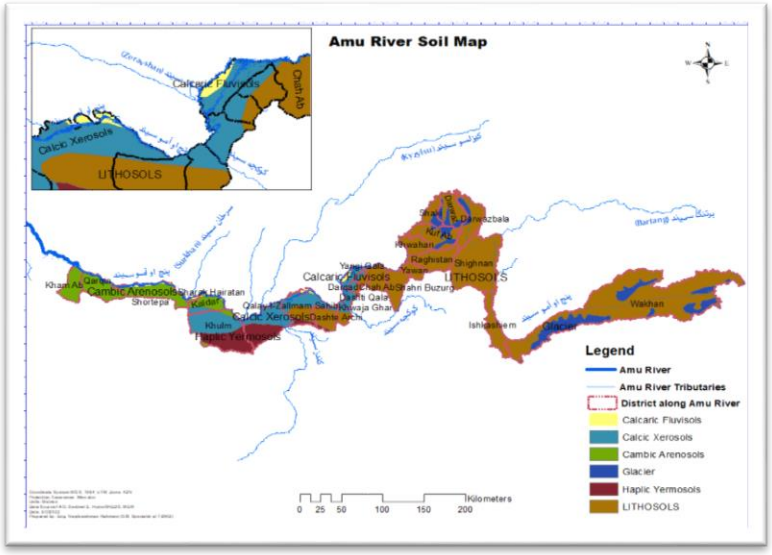


Figure.6 Soil type of the study area

A)Fluvisol is one of the 30 soil groups in the FAO soil classification system. Fluvisols are soils commonly found in topographic areas that have been deposited in coastal lowlands during periodic flooding by surface water or groundwater, are not particularly resistant to water, and are easily eroded. Degradation and destruction, the banks of the Amu River are also the most degraded of this type of soil (Fao, 2008).

B) Xerosols

Soils of the deserts, with low levels of organic matter. Subject to wind erosion and concentration of soluble salts (Fao, 2008).

C) Arenosols are sandy textured soils with a poor soil profile without significant development. They are only built temporarily and can keep a small amount of moisture in themselves, which easily decomposes and disappears during floods. Most of the banks of the Amu River have the same type of soil The river causes a lot of destruction in the turbulent state (Fao, 2008).

Figure.7 Fluvisols soil [FAO 2008]

figure.8 Arenosols soil [FAO 2008]

figure.9 Xerosols soil [FAO 2008]

6. Normalized Difference Water Index (NDWI)

NDWI = (G-NIR)/(G+NIR)

The Normalized Difference Water Index (NDWI) is derived from the Near-Infrared (NIR) and Green (G) channels. This formula highlights the amount of water in water bodies.

An alternate method of calculation uses the NIR and Short-Wave Infrared (SWIR) channels [(NIR-SWIR)/(NIR+SWIR)]. The amount of water present in vegetation primarily affects the spectral reflectance in the SWIR channel. The information about vegetation contained in the SWIR channel is unique. NDWI should be considered as an independent vegetation index (Yuksel et al., 2008).

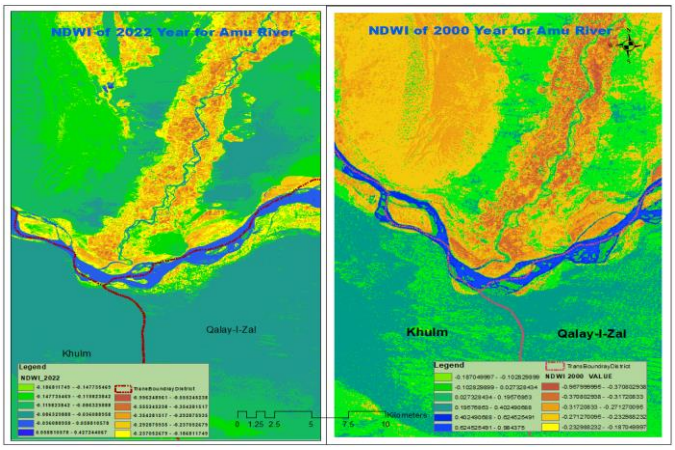


Figure.10 NDWI Analysis Map of huge degraded area

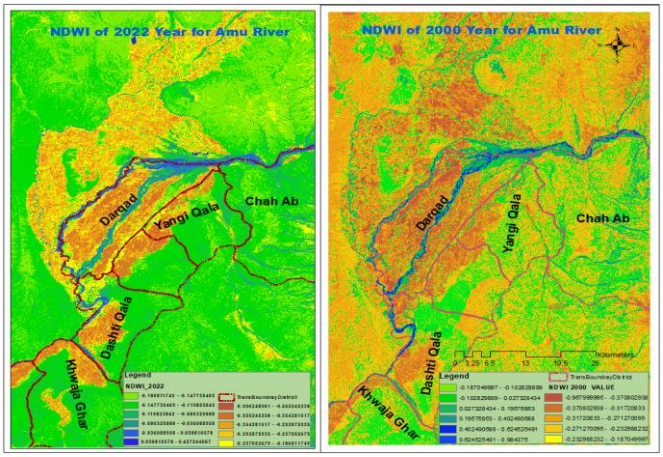


figure.11 NDWI Analysis Map of huge degraded area

The below table represent the result of NDWI analysis in Amu River Basin from 2000-2022. And degradation based in Provinces and districts.

Table.2 Result of NDWI Analysis of soil degraded in study area by author.

Provinces	Districts	River Bad from Zero Point in 2022 KM^2	River Bad from Zero Point in 2000 KM^2	Degraded area from 2000 to 2022 KM^2	Area Under Threat KM^2
Badakhshan	Darwazbala	3.33362	2.4441	0.88952	2.797997358
Badakhshan	Wakhan	0.664008	0.364411	0.299597	100.0118139
Badakhshan	Ishkashiem	7.130178	2.88875	4.241428	13.67747973
Badakhshan	Shighnan	20.738598	14.128903	6.609695	9.19639099
Takhar	Khwaja Bahawuddin	0.198017	0.077386	0.120631	4.740491
Takhar	Yangi Qala	0.507766	0.185391	0.322375	4.617019
Balkh	Sharak Hairatan	15.351307	6.888052	8.463255	8.356076
Balkh	Shortepa	162.835017	79.649519	83.185498	114.502303
Takhar	Chah Ab	15.741514	5.914243	9.827271	6.055089
Badakhshan	Kuf Ab	0.420048	0.364556	0.055492	0.388463451
Badakhshan	Shaki	3.079708	2.004019	1.075689	1.414418911
Kunduz	Dashte Archi	0.814574	0.820624	-0.00605	0.876267
Kunduz	Imam Sahib	74.134048	47.020759	27.113289	163.930124
Kunduz	Qalay-I-Zal	53.491842	31.632986	21.858856	78.864828
Balkh	Khulm	8.613001	6.616963	1.996038	15.390958
Jawzjan	Kham Ab	9.043788	5.536243	3.507545	1.358109
Jawzjan	Qarqin	81.918165	35.596937	46.321228	21.731783
Badakhshan	Shahri Buzurg	2.815787	1.323256	1.492531	0.214532755
Badakhshan	Yawan	1.300874	0.92603	0.374844	0.227781874
Balkh	Kaldar	61.866415	28.850373	33.016042	60.431881
Takhar	Darqad	63.171519	28.29074	34.880779	311.744602
Takhar	Khwaja Ghar	0.503731	0.719454	-0.215723	1.028796
Takhar	Dashti Qala	17.16727	8.67136	8.49591	34.157924
Badakhshan	Raghistan	1.271609	0.653421	0.618188	-0.104330486
Badakhshan	Khwahan	5.101972	2.568693	2.533279	3.488874335

Total Degraded Area	607.880756	314.137169	297.077207	959.0996728

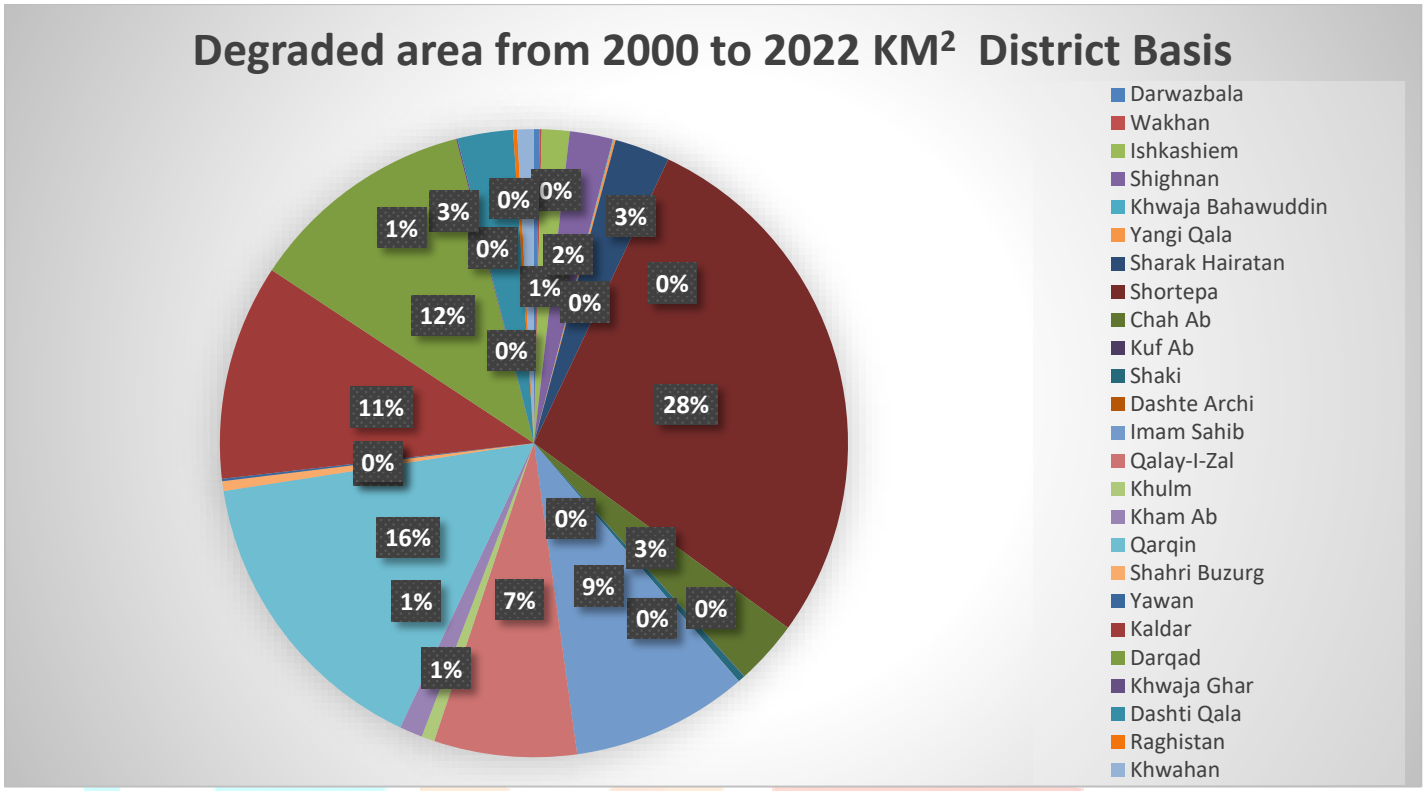


Figure.12 Result of NDWI Analysis of soil degraded in study area.

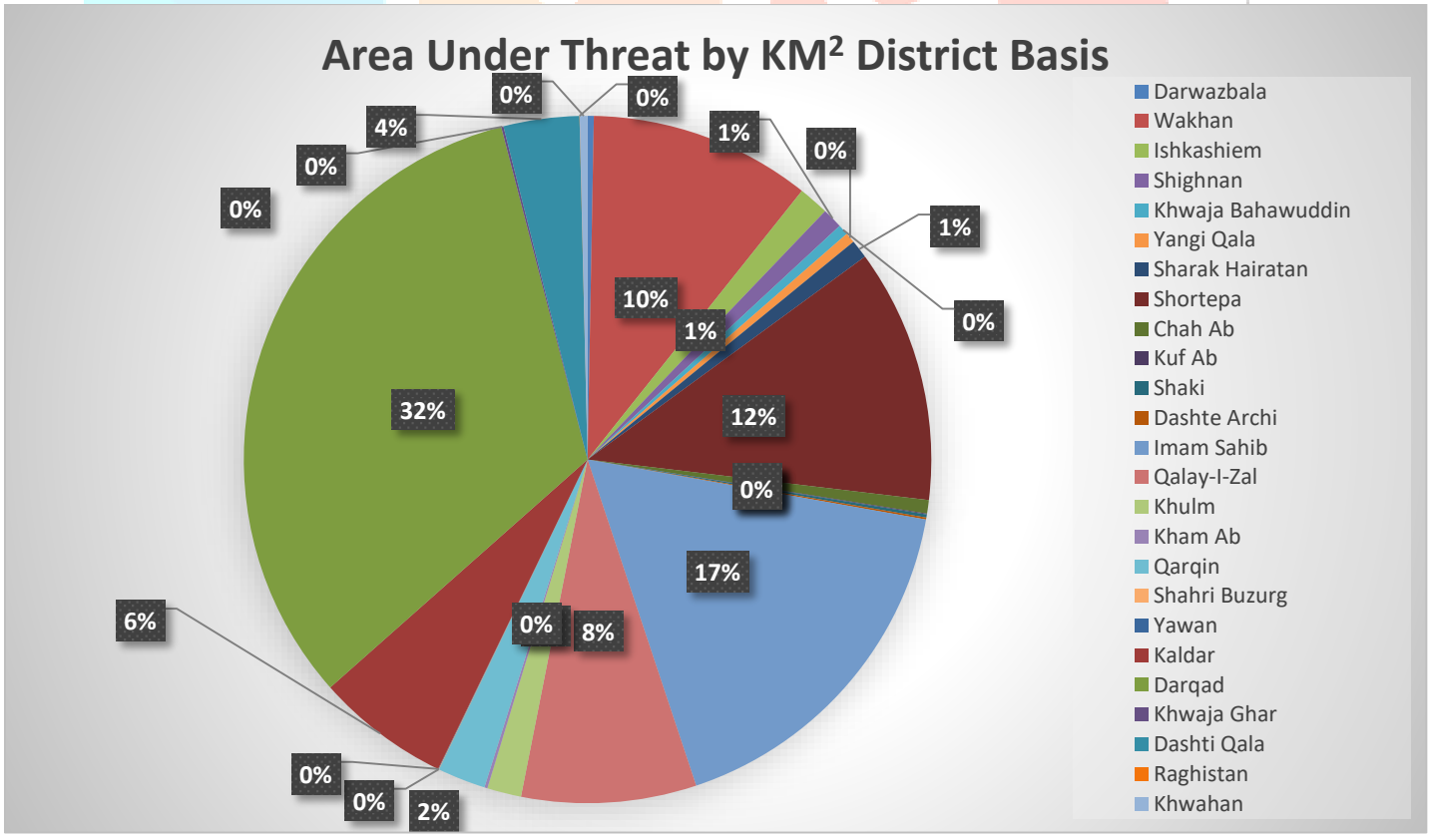


Figure.13 Result of NDWI Analysis of soil Under Threat in study area.

7. Land use/ cover Classification

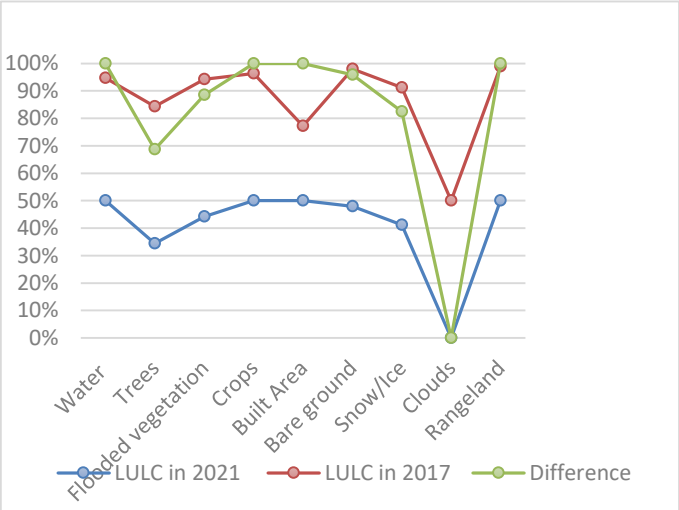
In this study, Sentinel-2 10m land use/land cover classification was employed to prepare the study area's land use/ cover map. In this study, the best results were obtained Using this classifier, the Amu River basin was classified into nine land use/ cover classes: Water, Trees, Flooded Vegetation, Crops, Built Area, Bare ground, Snow/Ice, Clouds, and Rangeland. the study area was carried out in order to observe the relationship between the 2017 and 2021 change detection, which observe the value of water bodies increased and trees are other classes decrease because those are degraded by Amu River (Yuksel et al., 2008).

Degradation of Land use & Land cover 2017-2021.

Class Definitions	LULC in 2021	LULC in 2017	Difference
Water	52664.86	47088.91	5575.95
Trees	114.06	165.91	-51.85
Flooded vegetation	2205.5	2492.01	-286.51
Crops	176469.46	163538.69	12930.77
Built Area	22444.01	12202.88	10241.13
Bare ground	1410945.69	1471534.09	-60588.4
Snow/Ice	239271.2	290063.95	-50792.75
Clouds		0.05	-0.05
Rangeland	1885209.68	1842377.29	42832.39
Total	3789324.46	3829463.78	-40139.32

Table.3 Degradation of Land use & Land cover 2017-2021 by author.

Degradation of Land use & Land cover 2017-2021.



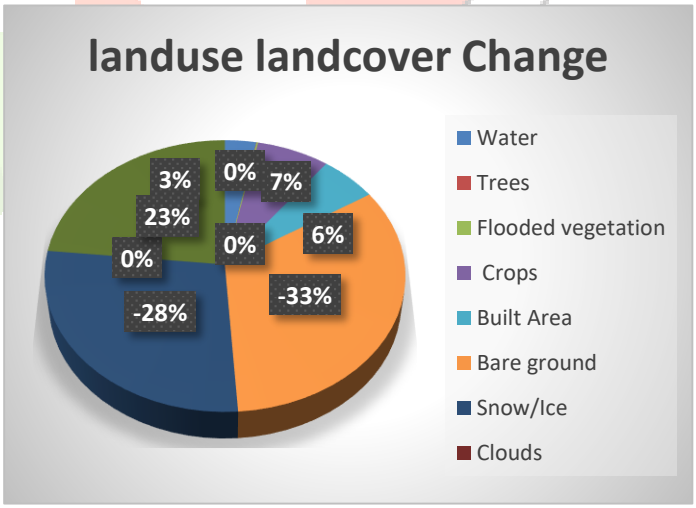


Figure.14 Percentage of Degradation of Land use & Land cover 2017-2021 Figure.15 Percentage of change in Land use & Land cover 2017-2021

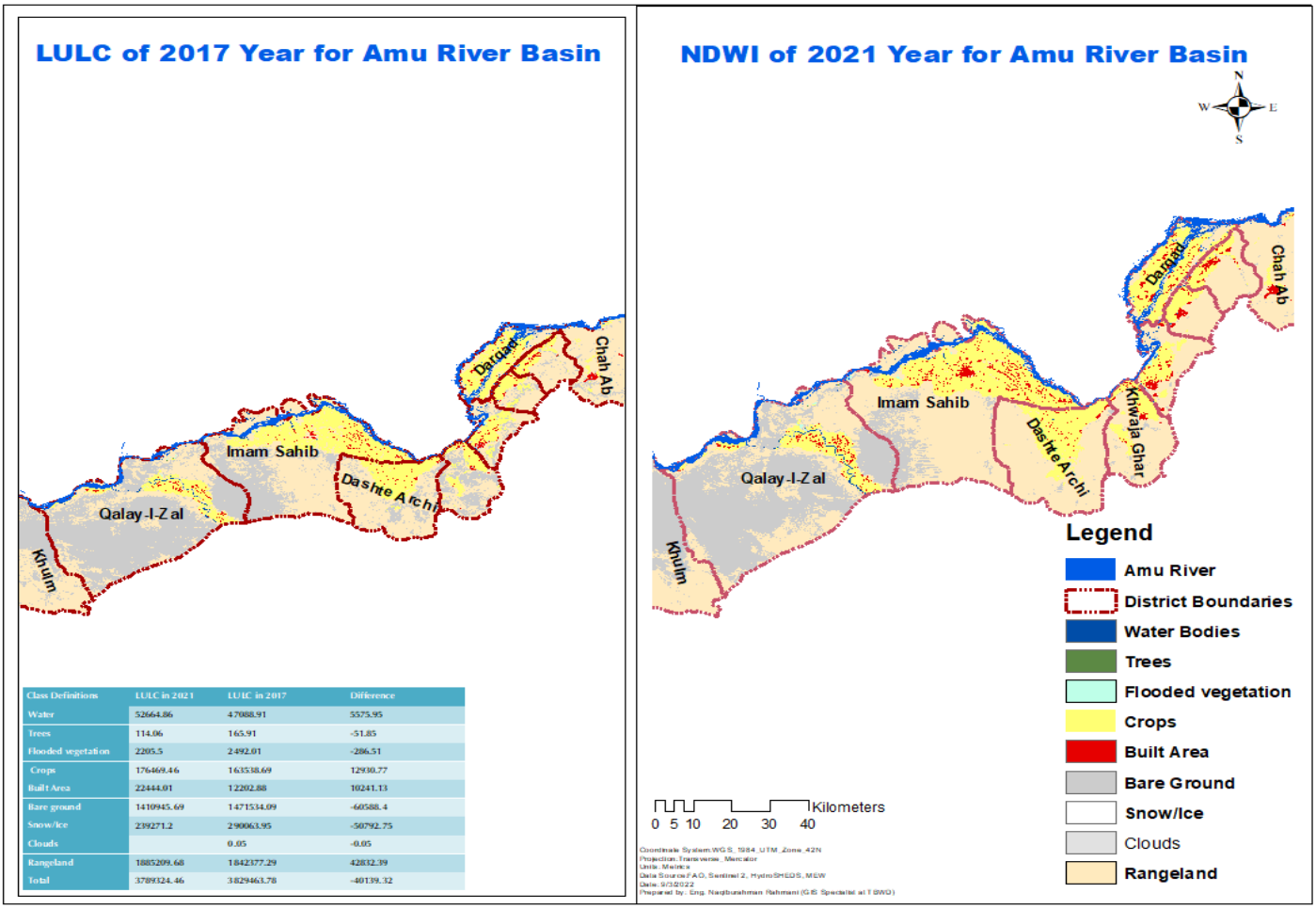


Figure.15 Degradation of Land use & Land cover 2017-2021 showed in map by author

8. Result

Wakhan District, Badakhshan Province:
There were 8 border pillars in this district, all of them have been destroyed due to natural disasters, and 8 sub-pillars are present in Panjah Fort, 149.5 acres of land and mulch have been destroyed.

Ashkashem district:
Among 21 border pillars in the mentioned district before the 80s, but now there are no traces of them. In this district, 2120.5 acres of agricultural land and mulch have been destroyed.

Petitioner's district:
A total of 2.533 square kilometers equivalent to 253.3 hectares of Jat villages in Bandak, Kamar, Gaji, Safid Ab, Shahank, Ish Ab have been destroyed, and 20 border pillars that existed before have been completely destroyed due to natural disasters.

Shaghnan district:
Not only the destruction of the beaches caused the destruction of the agricultural areas, forests and mulches, but it also caused social problems and destroyed only 1200 houses in the village of Pajur.In this district, 3304.5 acres of agricultural land and mulch have been destroyed in the following villages: Sarcheshmeh, Dinar, Shadoj, Pajur, and Mahrukh.

Shahr Bozor district:
Overall, 1,350 to 1,400 acres of agricultural land and forests have been destroyed in the villages of Jat Aviz and Payan Mord. In recent years, when the development programs of Jat villages were active at the provincial level, 4.5 kilometers of a small canal was built. 6 border pillars that were previously in the villages have been destroyed. Mamek to Gharjak of this district has completely disappeared and practically does not exist.

Raghistan district:
This district is rocky from the north and south sides, and the effects of the destruction were insignificant. It has destroyed 309 acres of land in the villages of Afshasar and Vidisha, agricultural lands and forests.

Yavan district:

The destruction of the coasts is insignificant and includes agricultural areas, which is 185 acres of land, but the area under threat is very large compared to the existing lands, that is, 760 acres of land in this district there is a lot of agricultural land, because other areas of this district have rocky shores.

Chah Ab District, Takhar Province:

Approximately 4,910 acres of agricultural land and mulch have been destroyed, and the cause of that is the floods that flow from Tajikistan.

Khaja Baha district of parents:

In Khaja Baha the destruction of beaches has not only caused the destruction of agricultural lands, but also caused social problems. And 170 Darband Havilis have been destroyed in the Arab villages of Kakal and Bai Dengag. The destruction of agricultural lands in this district is only 60 acres.

Dargad district of Takhar province:

The most effected district in Takhar Province is Dargad which is under serious destruction due to the division of the sea into three branches, and most of the area of this district is located between the branches of the sea, and each branch of the sea has turned the shores of the sea into a sea bed. It is located on the shore of Balkh Province along the Amu Sea. In this district, 100 residential houses have also fallen prey to the sea bed. 17,440 acres of agricultural land has been destroyed in this district.

Khaja Ghar district:

In this district, the agricultural land has not been lost, in the area of the sea bed that was identified before the year 2000, agricultural land has been built.

Yengi Qala district:

The destruction of the coasts from the area of Yatim Tipeh to the village of Sangalakh has destroyed 161.15 acres of agricultural land. Needless to say, the zero point that was previously determined between Afghanistan and Tajikistan is not known as the result of the destruction caused by Tajikistan with unilateral fortifications of the coasts. And the border signs are currently in the area of Tajikistan.

Imam Sahib Kunduz District:

The destruction of the southern shores of the Amu Sea is not only the agricultural lands and forests, but also the total and partial destruction of 300 residential houses and the total destruction of 3 shrines. In this district, Bastar Darya, about 13556.5 acres of land has changed its direction towards Afghanistan, and everything that was in this area has been destroyed.

Qala Zal district of Kunduz:

In Qala Zal the Amo sea bed has destroyed 10,925 acres of land, which includes agricultural land, forests, villages and residential houses.

Kaldar district of Balkh province:

Kaldar district of Balkh province is extremely important from the point of view of its geographical location and its available water capacity due to the selection of the water inlet to the irrigation canal and the production of electricity in Ghoshtipeh. Its lands have been lost and it has become the sea. This district is located on the border of Tajikistan and Uzbekistan. It has a border of 15.6 kilometers with Tajikistan and a border of 39.165 kilometers with Uzbekistan. In total, it has the villages of old Kaldar, Bozareeq, Taze Erig, Aq Masjid, Kadarig, Qoran Toqi, Pastoqi, Erig. In total, 811 residential houses, 11 mosque mihrabs and 8 school buildings have been destroyed. A total of 16,508 acres of agricultural and mulched land in Kaldar district of Balkh province have been destroyed by the sea. Tajikistan and Pakistan have caused all these destructions.

Shahrak Haraytan district:

In Shahrak Haraytan, the Amu River bed has destroyed 4230 acres of agricultural land on the Afghan side, which includes agricultural land and mulches. In this district, the area under the threat of the Amu River bed is 11850 acres.

Shortipeh District:

This district is considered to be the most affected district from the point of view of coastal destruction in the Abriz Amu basin on the Afghan side. It is located in Balkh province. The destruction of agricultural lands includes Malchers, residential houses and schools in this district. If the Afghan government does not consider

measures to protect the sea coasts in this district, in the not-too-distant future these lands will be separated from the geography of Afghanistan and will include the lands of Afghanistan's northern neighbor, Turkmenistan.

Qarqin district of Jawzjan:

Qarqin district of Jawzjan Province is one of the most affected district of this province. In total, 23,160 acres of agricultural lands, grasses, schools, and residential houses have become prey to the seabed due to the destruction of the sea shores in this district.

Kham Ab District:

In Kham Ab, 1753.5 acres of land have been destroyed and 5200.5 acres of land are under threat from the sea coast.

Kof Ab District:

In this district, the destruction of the shores of the Amu Sea includes agricultural areas and pastures, and it is almost negligible. In this district, 27.5 acres of land have been completely destroyed and 402.5 acres of land are under threat.

Shaki district:

The total destruction area of 535 acres of agricultural land and mulch has been destroyed and 2245 acres of agricultural land is under threat in Shaki.

Dasht Qala district:

In Dasht Qala, the destruction includes agricultural lands, residential houses, and public facilities. In this district, the total destruction is 4,245 acres, and the area under threat is 25,660 acres.

Khalm district:

In this district, the coasts of 995 acres of agricultural land and mulch have been destroyed, and 1,2015 acres of land are under threat.

9. Recommendations

Adaptation

Choosing the type of work consolidation:

The nature of sea shore consolidation is selected according to the following conditions
(Regarding the operating forces above work consolidation, for example, the amount of operating power from the flow and flow speed.

a. Availability of suitable building materials around the building.
b. The shape of the beaches and their constituent lands.
c. Comparative economic analysis and construction conditions.

In strengthening the coasts, the task of building elements that work under water most of the time is heavier because on the one hand they are constantly affected by water and on the other hand they perform the task of supporting the upper parts, so if any threat from this area affects the lower parts There is water in the mentioned buildings, in order to fix them, specific measures should be taken during the design and construction to remove the curvature of the water, which should also be directed towards the shore (Sepa, 2008).

In general, consolidation works are divided into two major categories, which are:

1. Consolidation of direct work
2. Consolidation of indirect work

Direct work consolidation is done directly above the beaches, since these buildings permanently cover a certain length of the beaches, these buildings are also called sustainable work consolidation. It is protected and strengthened indirectly. Buildings are not built directly on the shores, but they are built in front of them to reduce erosion forces.

9.1 Main goals of regulating the flow of the seas:

A set of measures that are adopted to regulate and control the flow of sea water and maintain the shape and course of the seas is called the regulation of the seas. The conditions to be built along the width or length of the sea are collectively known as sea regulating buildings. The basic objectives that must be met as a result of regulating the seas can be listed below.

9.1.1 Controversy with the destructive power of floods:

Floods have submerged fertile agricultural lands and residential areas, taking away people's vital facilities, their assets and even their lives. Statistics show that a large number of such incidents occur every year in different countries of the world. It is irreversible. In general, all countries are more or less affected by the erosion of sea coasts, but the effect on the population varies according to the situation of different regions. The table below shows the percentage of displaced people of the continents due to all natural calamities in 2010 and 2011, which is the most It is in the Asian continent and the least in the Antarctic continent.
mainly, the reason for their displacement is hydrological calamities, which include floods. The storm and mass movement of moisture defense measures against floods are all included in the first-class measures, the mentioned measures include the construction of one type or at the same time several types of the following buildings.
Consolidation or embankment of the shores in such a way that they can maintain the flow of flood waters within a certain path or certain dimensions. Increasing the width of the depth and straightening the path of the sea so that it can pass as much as possible the construction of secondary routes (channels) next to the main sea routes, so that during high tides, a certain amount of water can be passed and diverted from multiple routes. the construction of storage bowls for flood values(Sepa, 2008)

9.1.2 Water transport:

In many countries, the seas are used for shipping and other types of water transportation, since such conditions are not available in our country, so it is enough to say that the seas that are used for water transportation must have a route. The depth, width and speed should be suitable for shipping, and the water transport should be able to move easily in them and change its direction when necessary.

9.1.3 Control of transferred materials:

The issue of controlling flammable substances in the seas is considered to be one of the most important and fateful issues in the regulation of the seas, which is almost of decisive importance. The basic purpose of controlling the transported substances is to maintain the stability of the sea bed and shores and to prevent unfavorable changes in the state of the sea. It is the route of the sea. The regulation of the sea in order to control the transported materials requires that such buildings be built in suitable places that can prevent the creation of holes, curves and bends (YUKSEL Aladdin, 2001).

9.1.4 Guiding and justifying the current condition of the river:

Hydro-rolled buildings such as canals, cisterns, retaining walls, bridges, etc. are constantly under the threat and direct attack of water flow, for this reason, in the previous and later parts, the same buildings along one coast or both coasts for certain and relatively large lengths. Justifying walls, regulating walls and retaining walls are built. The length and distance between these walls are selected in the ranges that can safely pass the calculated amounts of flood waters in the locations of bridges, culverts, etc. The shape of the justifying walls is planned. A part is chosen to direct the sea water towards the passages under the bridges or the overflows (David Molden, 2002).

9.1.5 Stabilizing the sea route:

If the sea shores are made of weak soils and are threatened by washing, such shores should be strengthened. The strengthening of the sea shores can be in the form of paving stones, concrete and iron concrete or retaining walls and sheet nails. It is possible in some cases. Consolidation of the sea floor is also necessary. Consolidation of the sea floor (sea bed) is done in places that are under severe threats of washing and its longer duration will lead to a greater risk. It takes place. One of the important measures that is of great importance in making the sea route straight is to make the route straight, the more straight the sea route is maintained, the more stable the sea route will be (Andrei & Jean, 2012; Bariteau et al., 2013).

9.1.6 Controversy with the effects of underground water in destroying the shores of the Amu Sea:

Under certain hydrogeological and morphological conditions, underground water can play an important role in the destruction of sea coasts. For example, if there is an underground water supply dam in the picture below, and the sea level fluctuates a lot during the seasons, in this case, when the sea level is low(Ahmed & Fawzi, 2011; Halima & Maria, 2021).

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