

# Evaluation of the Impact of Heavy Metals from Oil and Gas Activities on Vegetation in Isoko South LGA of Delta State

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## Abstract

This study evaluate the impact of oil and gas activities on vegetation in Delta State specifically focusing on Isoko South Local Government Area, including the areas of Olomoro and Igbide Communities. The heavy metals investigated were Cu, Pb, Ni, Cr, and Cd, the sample locations were Olomoro Control , Olomoro1, Igbide 1 which was 15 meters away from flare stack and Igbide control sample was taken in the community, a Garmin GPSMAP 64SX, a 100ml beaker, steering rod, petri dish, analytical oven, funnel, cottonwool, silica gel, Sodium Sulphate, Dichloromethane Or n-Hexane, analytical syringe, Agilent Gas Chromatographic 6890, GBC AA Savanta (AAS), measuring cylinders, filter papers, nitric acid and hydrochloric acid (HNO<sub>3</sub> and HCl) were used in the lab. The results obtained showed a high concentration level of Cd, in all samples from the four sample points, records showed 0.74, 0.38, 0.25 and 0.59mg/kg which were far above WHO permissible limits of 0.02mg/kg, Pb was seen to be 4.91, and 2.31 mg/kg in Olomoro in both Control sample and sample point 1 which is also way above the WHO permissible limits of 2mg/kg, while that of Ni, Cr , and Cu also showed results of 0.28, 0.87, 0.38 and , <0.001, which were within the WHO limits of 10 and Cu, 1.3, 6.89, 6.34, 2.42, 4.90mg/kg against the international permissible level of 10 mg/kg, this result is an indication that there is heavy metal pollution on the vegetation in the studied areas.

**Keywords – Gas flaring, heavy metals, Vegetation contamination, Environmental pollution, Niger Delta**

## I. INTRODUCTION

Gas flaring, which is the burning of natural gas during oil extraction, with a brilliant wavering light [1] has had several negative impacts in Isoko south LGA, (housing Olomoro, and Igbide flow station) all in Delta State. It is a contributor to soil pollution, as the flare from these flare stacks are depositing toxic gases and particle matter into the soil. The health of the local communities is impacted by this pollution causing respiratory and other health problems. Also, there are environmental effects of gas flaring. It is a source of climate change as it emits greenhouse gases, increases or aggravates global warming. Black carbon is also produced by the flares and deposits on vegetation and water bodies, disrupting ecosystems and biodiversity. Black carbon is also emitted by the flares, and it deposits on vegetation and water bodies to cause damage to the ecosystem and biodiversity.

The effects of gas flaring on vegetation are studied by measuring several aspects including air quality, soil pollution, direct exposure to heat and gas pollutants released during flaring. Scientists usually compare vegetation health, species composition, and biodiversity of the gas flaring areas with those that are not affected by the impact of the gas flaring to learn the magnitude of the effect. Common methods to collect data used in such investigations include remote sensing, field survey, and laboratory analysis [2]

Flaring of gases may cause negative effects on plants. The burning emits such pollutants as nitrogen oxides, sulfur dioxide, which may cause damage to plants, slows down growth, and destroys leaves. Moreover, the heat produced may scald vegetation directly and change soil chemistry, which influences nutrient availability and microbial community necessary to support plant growth. The investigation by [3]

mentioned that, with prolonged exposure to gas flaring, a decrease in biodiversity, habitat destruction, and degradation of ecosystems might be observed in the affected regions. Gas flaring emits various pollutants that can have direct and indirect impacts on vegetation. These pollutants include nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), particulate matter, and volatile organic compounds (VOCs).

## II VEGETATION

Vegetation refers to the collective plant life or plant communities found in a specific area environment. It includes all forms of plants, from trees and shrubs to grasses, mosses, and even aquatic plants. Vegetation plays a critical role in ecosystems by providing habitat, producing oxygen through photosynthesis, stabilizing soil, and influencing climate patterns. The term can describe the general plant cover in a region, such as tropical rainforests, grasslands, or deserts, or it can refer to specific plant communities, like a forest of oak trees or a meadow of wildflowers. Vegetation is a key component of the natural environment and is essential for the survival of many species, including humans. The majority of the body's active nutrients come from plants. Depending on the species, plants may provide a variety of nutrients, including carbohydrates, proteins, lipids, minerals, and vitamins. Livestock, particularly omnivores like goats, cows, grass cutters, rabbits, and so on, rely on vegetation for sustenance. Some animals, such as bushmeat, which does not dig, rely on vegetation cover for shelter. Cassava and oil palm trees, which are rather noticeable, are located near residential areas and farms. These two types of vegetative cover are common around gas flaring sites in the Niger Delta, and they are both eaten by locals. According to [4], gas flaring is known to impact several plant species, particularly in terms of growth and production.

For example, according to [5], when one moves away from gas flares, cassava loses length and weight while increasing its amino acid and total sugar levels. Additionally, the scientists noted that a decline in starch and ascorbic acid (vitamin C) content was

similarly associated with these declines in tuber content. Research out of the Niger Delta found that the majority of locals (77%) believe that gas flaring has an impact on farming and the environment [6]. According to [7], gas flaring is also linked to acid rain and deforestation. Soil fertility may have been affected if there were effects on crop growth and production.

Soil nutrients are essential for plant development, and this might cause their loss. According to [8] plants are used for their bioactive and pharmacological components. The therapeutic capabilities of bioactive constituents are heavily influenced by their makeup. Gas flaring's impact on plants' bioactive and nutritional components was shown. [9] found that gas flaring might alter the anti-nutrient compositions of several commonly consumed vegetables, including smell leaf, bitter leaf, water leaf, and fluted pumpkin leaf, including alkaloids, phytate, oxalate, saponin, tannin, and cyanogenic glycosides. Gas flaring is known to physically harm plants close to the flare stack, according to [10]. This harm can occur in the areas of phytochemicals (alkaloids, tannins, cyanogenic glycosides, phytate), proximate composition (moisture, ash, protein, carbs), micronutrients (calcium, sodium, magnesium, potassium, phosphorus, and riboflavin), and vitamins (E and C). Additional consequences may follow. Furthermore, gas flaring has the potential to change microbiological and physiochemical soil quality indicators.

Gas flaring often affects a number of important soil quality characteristics, including pH, temperature, soil moisture, and the microbial community. In most cases, microorganisms are crucial to the biogeochemical and nutritional cycles. Gas flaring is affecting soil fertility and production for food crops including cassava, plantain and yam, according to a survey research in Delta State.

Gas flaring, which is a result of oil exploration, leading to the burning of natural gas during oil extraction, may cause negative impacts on vegetation. The burning emits pollutants such as nitrogen oxide and sulfur dioxide that may cause damage to the

plant, retard growth, and destroy foliage. Also, the heat emitted may directly burn flora and change the soil chemistry, which determines nutrient availability and microbial communities needed by plants to grow. In the long run, the biodiversity, habitat destruction and degradation of the ecosystem around the affected areas may be a result of long-term gas flaring exposure. Gas flaring releases a number of pollutants that may directly and indirectly affect vegetation. These contaminants are nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), particulate matter, and volatile organic compounds (VOCs). Plants play a crucial role in the stability of the ecosystem, soil health, water management, and supporting the wildlife. This knowledge of the impact of gas flaring on vegetation, in this study has aided in the determination of the overall health and stability of certain vegetation. It will also make us aware of the current state and condition of vegetation in this area of study.

## **IMPACT ON VEGETATION**

### **1 Impact of Air Pollution on Vegetation:**

The main causes of air pollution are nitrogen oxides and sulfur dioxide. They can inhibit nutrient uptake, decrease photosynthesis rates, and cause plant tissue. These pollutants may cause leaf necrosis, chlorosis (yellowing of leaves) and early drop of leaves which may be caused by large amounts of the pollutants. The negative impacts of gas flaming have been reported in many studies on the effects on vegetation health. Plant tissues may be damaged, photosynthesis may be inhibited and plant modification may occur due to air pollutants released during flaring, such as sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>) and particulate matter metabolism. Studies have demonstrated that sensitive vegetation species experience apparent symptoms of the stress, low growth rates, at a greater degree of flaring emission release [11].

### **2 Impact of Acid rain Deposition on Vegetation:**

Acid rain is a result of sulphuric acid, which is formed when sulphur dioxide reacts with atmospheric moisture. Acid rain can leach essential nutrients from the soil, such as calcium, magnesium and potassium,

leading to nutrient deficiencies in plants. Acidified soil can also release toxic elements like aluminum, which further damages vegetation, this is because it removes minerals and nutrients from the soil [12].

### **3 Impact of Heat and Radiation on Vegetation:**

Gas flaring generates intense heat and radiation, which can directly scorch vegetation near flare stacks. The production of CFC continues to destroy the ozone layer, hence the resulting in protein denaturalization and DNA damage, thus plants exposed to high temperatures may experience tissue damage, wilting, and reduced growth rates, increase in soil temperature can affect the root health and microbial activity which is crucial for nutrient cycling [13].

### **Impact of Soil Contamination on Vegetation (soot):**

Gas flaring and burning of biomass can produce and deposit soot on plants and cause increase temperature leading to reduction in soil surface, altering soil chemistry and physical properties. Accumulation of pollutants can lead to soil acidification [14].

Pollutants like sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides can cause acid rain, which lowers soil pH.

Ammonia from fertilizers can convert to acids in the soil, they eliminate more sensitive species and also disrupt the photosynthetic mechanism by reducing the quality and quantity of plant yield ([15].

Heavy metals can disrupt soil chemistry and contribute to acidity, they can also disrupt nutrient uptake and the movement of nutrients around the plant. These processes reduce the soil's ability to neutralize acids, leading to increased soil acidity.

Accumulation of pollutants can lead to soil compaction, Pollutants like heavy metals and chemicals can disrupt soil structure and harm beneficial organisms. Particulate matter and combustion by-products emitted from flare stacks can settle directly onto vegetation surfaces, coating leaves and stems with pollutants. This can hinder, reduce gas exchange, and impair plant growth. Direct deposition of particulate

matter and combustion by-products from gas flaring can reduce gas exchange by:

**Clogging Stomata:** Pollutants can block the stomata (small pores) on leaves, reducing the ability of plants to exchange gases such as carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>). **Impaired Photosynthesis:** Reduced gas exchange limits the intake of CO<sub>2</sub>, essential for photosynthesis, and affects the plant's ability to release oxygen, impacting overall plant growth and health. These effects collectively hinder the plant's ability to perform essential physiological functions. The key gases involved in gas exchange that can be impacted by pollutant deposition are:

- Carbon Dioxide (CO<sub>2</sub>): Plants take in CO<sub>2</sub> through their stomata for photosynthesis.

Pollution that blocks or clogs stomata reduces CO<sub>2</sub> intake, impairing the photosynthesis process.

- Oxygen (O<sub>2</sub>): Plants release O<sub>2</sub> as a by-product of photosynthesis through their stomata. Reduced gas exchange affects the release of O<sub>2</sub>, impacting the plant's ability to support surrounding wildlife and maintain ecological balance.

- Water Vapour (H<sub>2</sub>O): The process of transpiration, the release of water vapor through stomata, is also influenced. This process can be destabilized by pollutants, which cause water stress, and impact plant health.

**Nutrient Deficiency or Toxicity:** This Varies in nutrient levels can affect the growth of plants. An example is that when the levels of nitrogen are low, plants with high nitrogen requirements may grow slowly; on the other hand, high levels of specific nutrients may cause toxicity. This results in a compacting of soil particles and decreased porosity resulting in soil compaction. Water infiltration in soil can also be decreased by pollutants accumulation in a multitude of ways [16].

**Soil Compaction:**

Chemicals and heavy metals are some of the pollutants that may initiate the clumping together of soil particles resulting in soil compaction. The soil is compacted resulting in reduced pores and thus reduced infiltration of water by the soil resulting in surface sealing. Pollutants may help in forming a layer that is hard and impermeable on the surface of

the soil. This layer covers water infiltration and causes increased runoff.

**Chemical Alterations:** Chemicals can change the chemical properties of the soil, including its pH or salinity. These shifts can impact the structure of the soil and diminish its capacity to absorb water. Pollutants may introduce a change in the chemical characteristics of the soil, e.g. its pH or salinity. Soil PH influences access to nutrient requirements. An example is the inability of nutrients such as phosphorus, calcium, and magnesium to be available in acidic soils, and toxicity. Metals such as aluminum may become soluble, which may damage delicate plants. Pollutants that are normally present in gas flare run-off are:

- Heavy Metals: Examples Lead, cadmium, mercury, arsenic.

Sources: Emissions from flaring and industrial processes.

Effects: Toxic to aquatic life, can accumulate in the food chain, and impair plant growth.

- Polycyclic Aromatic Hydrocarbons (PAHs): Examples Benzopyrene, anthracene, naphthalene.

Sources: Combustion by-products from gas flaring.

Effects: Persistent and carcinogenic, can disrupt aquatic plant growth and development.

- Volatile Organic Compounds (VOCs): Examples Benzene, toluene, ethylbenzene.

In this research we examined the effect of Gas flare on vegetation, knowing it is essential for ecosystem stability, supporting soil health, water regulation, and providing habitat for wildlife. Understanding how gas flaring affects vegetation, this study has helped us to assess the overall health and stability of vegetation. It will also bring to our notice the present state of the vegetation by also analysing heavy metal level in the vegetations in this study area.

#### IV MATERIALS AND METHODS

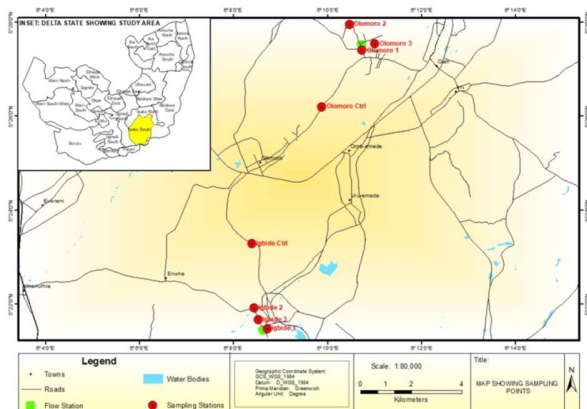


Figure 1: Showing Map of Study Location, SOURCE: (Suru and Tegu 2026)

**STUDY AREA**

The Isoko South Local Government Area is located in Delta State, Niger Delta, Nigeria. Olomoro and Igbide are communities in Isoko LGA, Lying low with an interconnectivity of rivers, streams and swamps, a wet land area with brackish and fresh water bodies in a soil dominated by mangrove forest with abundant vegetation including vegetation of mangroves in the coastal area , these communities depends on fishing, farming, and small scale trading, the Olomoro community is on Longitude 6<sup>0</sup> 10' 24.4''N and latitudes 5<sup>0</sup> 27' 25'' E, and Igbide on longitude 6<sup>0</sup> 08' 39'' E and latitude 5<sup>0</sup> 30' 54''N inset the map of study area in figure 1. All communities housing flow stations and flare stacks with heavy presence of oil and gas activities.

**1 Sampling Materials**

The site sampling was carried out with Garmin GPSMAP 64sx for accurate location tracking and mapping of sample sites, a Kestrel 5500 Weather Meter, to enable accurate weather tracking foe temperature, humidity and wind speed of the sample site, a 100ml beaker, steering rod, petri dish, analytical oven, funnel, cottonwood, silica gel, Sodium Sulphate, Dichloromethane Or n-Hexane, analytical syringe, Agilent Gas Chromatographic 6890, a beakers, GBC AA Savanta (AAS), measuring cylinders, filter papers. The reagents that were used were Nitric Acid and Hydrochloric Acid (HNO<sub>3</sub> and HCl)

**2 Sampling Method**

The vegetation samples were collected from the four locations, in Olomoro and Igbide, 2 sample points from each community, the control sample close to the community and 15meters from flare stack. The sample

was sub-sampled into a foil beg during transit, and dry at room temperature for 5-8 days. Following complete drying, the sample was ground using ceramic mortar and pestle. 2 grams of the ground material was then measured and placed in a glass beaker together with 20 millilitres of an organic solvent (either dichloromethane, or C<sub>6</sub>H<sub>12</sub> n-Hexane). Stirring the sample with a steering rod ensured an adequate mixing. Finally, the sample was filtered using a funnel, cottonwool, silica gel, and sodium sulphate. (Cottonwool removes visible impurities, silica gel removes invisible ones, and sodium sulphate acts as a dehydrating agent by removing moisture from the sample). Following filtration, the sample was left to concentrate for 1-2 hours before being subjected to gas chromatography. This involved adding 1 ml of n-Hexane to the concentrated sample, collecting 1 microlitre of the sample using an analytical syringe, and injecting it into the injector compartment of the GC. In the next 25 minutes, the sample was subjected to analysis. Air, helium, and hydrogen were the gases used by the gas chromatograph. The machine was heated by the air and hydrogen, and the sample was conveyed to the GC detector by helium, which served as the carrier gas.

The heavy metals were analysed, using (Liquid Samples: e.g. Water or Effluent) were a 20mL of sample was measured into a 100mL beaker with 5mL of Nitric and 5mL HCl, then heated for 10min and filter with filter paper and funnel, making a solute to 20mL and distilled, which was further taken to the AAS for metals determination.

**V RESULTS AND DISCUSSIONS**

TABLE 1: COORDINATES OF VEGETATION SAMPLE POINTS

Community	Station	Coordinate
Olomoro	Sample point	N05 <sup>0</sup> 27' 26.0'' E006 <sup>0</sup> 10' 48.3''
	Control	N05 <sup>0</sup> 26' 12.4'' E006 <sup>0</sup> 09' 53.0''

Igbide	Sample point	N05 <sup>0</sup> 21' 31.7" E006 <sup>0</sup> 08' 37.1"
	Control	N05 <sup>0</sup> 23' 17.5" E006 <sup>0</sup> 08' 23.6"

that most heavy metals stay stable in a polluted environment without altering chemically, and they linked the high concentration of the pollution to sources such as vehicle exhaust, manufacturing waste, metal smelting, and coal combustion. More so from our results in table 2, chromium (Cr) was also seen to have high concentration in Igbide control samples, which is 2.13 as against the international permissible limit of 1.30mg/kg, this result of high Cr was also reported in the study of [19], they also recorded elevated Cr, they attributed the high concentration of Cr in

TABLE 2 SUMMARY OF RESULT OF HEAVY METALS IN PLANTS SAMPLES (mg.kg)

### 3 Spatial Distribution of Sampling Locations

Results from table 1; showed the geographical locations of the various coordinates where the samples were collected in Isoko south local government Area in Delta State, Nigeria. The sample point 1 was used as the control in the Olomoro community, while in Igbide community the control was taken farther away from the flare stack area. The results in table 2 showed that copper (Cu) ranged highest in Olomoro control station out of the four sample results with its value to be 6.89, yet, this value was below the WHO permissible limit of 10, while that of Ni, and Cr also showed results of 0.28,0.87,0.38 and ,<0.001 which were within the WHO limits of 10 and 1.3, this result is in line with the study of [17] they in their study also experienced a low concentration of cu, and Cr, they attributed the low concentration to the high concentration to have been further seen in the soil samples in their studied location, It was also observed that the Igbide 1 and 2 sample locations showed Low presence of copper Cu, and Ni, with their value reported as 2.42, 4.90 also within the international threshold.

On the other hand the result for Pb, was seen to be 4.91 and 2.31 mg/kg in Olomoro in both Control sample and sample point 1 which is way above the WHO permissible limits of 2mg/kg this high rate of Pb, was also reported in the study of [18]. They said

plants to the bioavailability of heavy metal that has not been proven to be playing any role in the physiology of pants, they further stated that plants that are grown in Cr polluted soil will show severe

S/N	Sample Location	Cu	Pb	Ni	Cr	Cd
1	Olomoro control Area point 1	6.89	4.91	0.28	0.38	0.74
2	Olomoro Sample Point 2	6.34	2.31	0.87	<0.001	0.38
3	Igbide Control Area point 1	2.42	0.48	2.90	2.13	0.25
4	Igbide Sample Area Point2	4.90	1.59	<0.001	<0.001	0.59
5	WHO Limits	10	2	10	1.30	0.02

toxicity symptoms.

### 4 Heavy Metals Concentration in Vegetation

Furthermore, the results from table 2 also revealed a high concentration level of Cd, in all samples from the four sample points, records showed 0.74, 0.38,

0.25 and 0.59mg/kg which were far above WHO permissible limits of 0.02, this high result is also in line with the high concentration also record in [20] were they related the high Cd to combustion, vehicle exhaust, metal smelting e.t.c, more so studies have it that Cd is a highly toxic heavy metal and that it poses a high risk to living organisms, including human, animals, and plants. [21] in their review stated that Cd has hyperaccumulation capability and that certain plant species had the ability to retain it, this means that all the plant species that were sampled in these locations have hyperaccumulation capabilities. [22], in their study also revealed that Cd is a highly permeative or penetrating heavy metal that also poses real threat to the agricultural productivity. Cadmium, Lead, chromium been seen in concentration that are higher than international permissible level s in the vegetations under study in various samples that were analysed, which is a pointer that the vegetations in these communities, meaning that the habitat who are the end consumer the food chain are at risk.

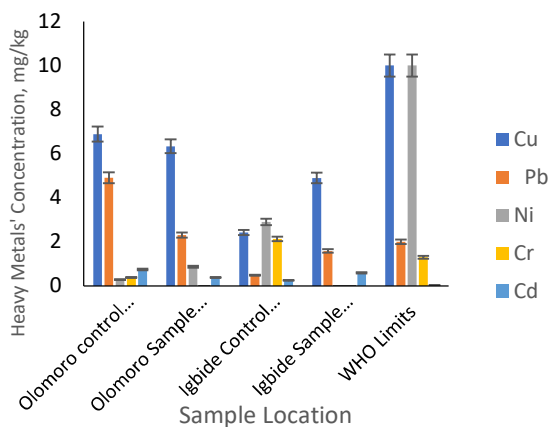


Figure 2: Graph showing Concentration levels of Heavy Metals in Olomoro and Igbide.

### 5 Comparative Analysis of Olomoro and Igbide Communities

The comparative analysis from the results presented in figure 2, it is clearly seen that both Olomoro and Igbide are polluted with Cd, showing highest in Igbide samples, it is also observed that Olomoro is densely laden with Lead heavy metal. According to research, lead poisoning in

plants reduces agricultural output by altering hormone levels, which in turn affects leaf area and stomatal conductance [23]. One will now see reasons why the vegetation in these communities under study are stunted and tending towards yellow in color. In general, it is clearly seen that these communities under study are polluted with heavy metal. Still [23] in their study illustrated with a schematic diagram how coal burning, waste incineration, industrial waste, gold mining gives rise to elementary mercury that leads to oxidation leading to Hg (II). In this part of the communities, there is high level of oil and gas exploration activities that leads to gas flaring activities hence these result. The result also showed that both communities exhibited low results in Cu, and Ni concentration that were 6.89,6.34, 2.42,4.90 and 0.28, 0.87,2.90 and <0.001mg/kg that were within the WHO permissible limits of 10 and 10mg/kg.

### VI CONCLUSION AND RECOMMENDATION

This investigation have demonstrated that oil and gas activities particularly gas flaring significantly contributed to heavy metal contamination of vegetation in Olomoro and Igbide communities of Isoko South LGA, Delta State. The study observed from our result that the concentration of heavy metals such as Cu, Pb, Ni, Cr and Cd in the communities under study in the four different location, with these communities all having gas flare stacks. The results of Pb, Cd, and Cr in these studied communities and the flare stack environ went beyond the both local and international permissible limits, the average results of Cu was 5.138mg/kg which was within the international permissible limit of 10mg/kg. The evaluated results of the vegetation in Olomoro control, and Igbide has shown that the vegetation in these communities where these oil and gas facilities/ flare stacks are, is laden with heavy metals, thus the vegetation is under environmental stress by the effects of oil extraction and gas flaring, resulting in the low growth of plants, soil erosion and biodiversity loss.

#### RECOMMENDATION:

We do therefore prescribe, stringent regulation, purer technologies, and rehabilitation, to be made, to counteract these harm. Government, industries, and community must collaborate to protect vegetation and ecosystem in the area surrounding gas flares. There should be regular check of air quality and vegetation health of the areas near gas flaring sites.

This would help identify the extent of damage and track improvements after mitigation efforts.

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