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Enhancing Organic Fertilizer Quality Using the EDAS Method: A Comprehensive Approach to Sustainable Agriculture

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ABSTRACT

Organic fertilizers originate from natural materials, including plant and animal substances, and supply crucial nutrients that boost soil health and crop yield. In contrast to synthetic fertilizers, which can harm soil quality and lead to pollution, organic fertilizers gradually release nutrients, enhancing soil structure and fostering microbial activity. By using organic fertilizers, farmers can enhance soil fertility, decrease reliance on chemicals, and support environmental conservation. This method not only increases crop production but also nurtures a healthier ecosystem, establishing organic fertilizers as an essential element of contemporary sustainable agriculture. Organic fertilizers are vital for sustainable agriculture as they enhance soil health, improve fertility, and promote microbial activity. B Organic fertilizers provide essential nutrients, including trace elements, improving crop quality and nutritional value. They also aid in carbon sequestration, helping to mitigate climate change impacts. Additionally, using organic fertilizers enhances resilience to climate-related stresses, boosts local food security, and fosters community engagement in sustainable practices. Overall, organic fertilizers are crucial for developing environmentally friendly farming methods that benefit both agriculture and the ecosystem. The process of creating organic fertilizer includes several essential steps. Begin by gathering organic waste, such as vegetable scraps, yard trimmings, and animal manure. Then, cut or shred the materials to speed up the decomposition process. Combine the waste in a compost bin or heap, ensuring a proper mix of carbon-rich (browns) and nitrogen-rich (greens) components. Keep an eye on moisture, maintaining a damp environment without water logging. Regularly turn the compost to facilitate aerobic decomposition. After several weeks to months, the materials will break down into a dark, crumbly substance, signaling that the organic fertilizer is ready for application. Nitrogen, phosphorus, Potassium, Magnesium, Sodium. Beef/ Dairy (%), Poultry (%), Swine (%), Sheep (%). Nitrogen is getting first place of the table and sodium is last place of the table.

1. INTRODUCTION

Inorganic fertilizers not only contribute significantly to soil pollution but also accumulate in food crops, vegetables, and fruits. For example, trace elements like cadmium and arsenic, present in fertilizers such as triple superphosphate, can build up in plants and enter the food chain, eventually reaching humans and potentially causing serious health issues. Bhandari examined the use of agricultural chemicals and their negative environmental impact in Nepal, concluding that these chemicals are regarded as potent tools in developed countries to boost agricultural productivity.[2] Tropical soils often face the challenge of soil acidity, which is marked by low pH, high aluminum content, calcium deficiency, and low organic matter, making them less productive. These soils are also prone to phosphate fixation, preventing phosphorus from being available

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to plants, thus requiring large amounts of phosphate fertilizers. Phosphorus binds to oxides and clay minerals, further exacerbating this issue. While soil acidity and nutrient deficiencies can be mitigated with lime and fertilizers, small-scale or resource-poor farmers often lack access to these solutions. Historically, agriculture thrived without synthetic chemicals, but artificial fertilizers, introduced in the mid-19th century, offered a cheap, powerful, and transportable alternative. Although effective in the short term, they have caused long-term problems like soil compaction, erosion, reduced fertility, and health risks from toxic chemicals in the food supply.[5] While the intensive use of inorganic fertilizers can boost crop production, it ultimately depletes soil fertility. To counter these negative effects, organic agriculture has emerged as an alternative approach, utilizing organic fertilizers. Organic fertilizers are becoming increasingly popular in many countries due to their eco-friendly and cost-effective nature. Organic farming is considered the best practice for preserving soil fertility and protecting the environment.[6] To reduce poverty and malnutrition and achieve self-sufficiency in food and fiber crops in the shortest time, agricultural intensification through multiple cropping, increasing cropping intensity, and using high-yielding varieties is essential. These efforts, crucial for national food security, require a comprehensive management approach that heavily relies on a balanced supply of plant nutrients. However, mineral fertilizers alone cannot address all soil nutrient deficiencies. With rising oil prices and dwindling natural resources, the cost of imported fertilizers is expected to increase in the coming years. Therefore, prioritizing the use of native organic resources and incorporating them into soil fertilization programs is essential. Promoting biogas technology is one way to achieve this, as it provides energy for various uses and produces high-quality bioslurry, which serves as an effective organic fertilizer.[7] The management of solid waste poses significant challenges for developing nations, as waste generation is rapidly escalating. To address this issue, there has been increased awareness regarding sustainability and technological advancements in solid waste management, aiming to minimize unnecessary waste production. The review also assesses the potential side effects of these organic fertilizers on soil, noting that their characteristics can vary based on the type of waste used and the differing chemical compositions of the fertilizers. This research offers insights into the potential management of biomass waste for organic fertilizer production and highlights the benefits of replacing chemical fertilizers with those derived from biomass waste.[11] Ukraine and Russia are key players in global agriculture, significantly contributing to the production and export of food and organic fertilizers. However, the ongoing conflict between these two nations has led to substantial disruptions in organic fertilizer supplies and agricultural output, resulting in rising food prices worldwide. To address these challenges, there is a pressing need to enhance the flexibility and openness of international trade in fertilizers and agricultural products. Additionally, promoting policy discussions, market transparency, and scrutiny is crucial, especially given the uncertainties in the global food market stemming from the war's disruptions. The insights from this research can assist scientists, economists, and policymakers in forecasting agricultural trends and formulating strategies to bolster the economies of affected countries, including Ukraine.[12] Organic fertilizers are naturally occurring materials derived from repurposed plant or animal materials provide essential nutrients for plants. These fertilizers can improve the soil's microbial population and its ability to retain moisture, while also improving nitrogen utilization efficiency and overall soil fertility, which ultimately leads to better-quality agricultural products. Utilizing solid organic manure to create eco-friendly compost can serve as an effective means to enhance soil fertility. However, alternative nutrient-rich organic sources that farmers can access are not widely advocated or promoted.[13] However, not all organic fertilizers are immediately available to plants; they require warm soil conditions to decompose and release nutrients. For a faster response, options like fish emulsion or seaweed extracts can be used, as they are water-soluble and readily accessible to plants. Foliar sprays can also be effective for early-season feeding. It's important to note that excessive fertilizer use can damage plants and contribute to groundwater pollution, making organic fertilizers a safer alternative due to their lower concentration compared to chemical fertilizers. This paper aims to promote the use of organic fertilizers in organic farming, contributing to the long-term preservation of agricultural land.[16]

2. MATERIAL AND METHOD

Alternatives:

1. Nitrogen: Nitrogen is an essential nutrient for plants, crucial for synthesizing proteins, producing chlorophyll, and supporting overall growth. It plays a significant role in fertilizers and affects both crop yield and quality.

2. Phosphorus: Phosphorus plays an essential role in energy transfer within plants, aiding in root development, flowering, and fruiting. It is a vital ingredient in fertilizers that boosts overall plant growth and productivity.

3. Potassium: Potassium is vital for plant health, as it manages water balance, activates enzymes, and facilitates photosynthesis. It boosts disease resistance, enhances crop quality, and is crucial for overall growth and development.

4. Magnesium: Magnesium is crucial for photosynthesis because it is a key component of chlorophyll. It also supports enzyme activity, facilitates energy transfer, and enhances nutrient uptake and overall plant growth.

5. Sodium: Sodium plays a significant role in plant growth by aiding in osmoregulation and nutrient transport. It helps activate enzymes and can boost photosynthesis, but excessive levels can be harmful.

Evaluation preference:

1. Beef/ Dairy (%): Beef and dairy cattle supply vital nutrients through their manure, improving soil fertility. They play a key role in agricultural sustainability, delivering high-quality protein and supporting economic stability in rural areas. **2. Poultry (%):** Poultry farming serves as a vital source of protein, offering both meat and eggs. Additionally, poultry manure enhances soil fertility, and the industry fosters economic development while encouraging sustainable agricultural practices.

3. Swine (%): Swine farming is an important provider of pork, offering high-quality protein. The manure from swine improves soil fertility, and the industry significantly contributes to rural economies and sustainable agricultural practices.

4. Sheep(%): Sheep farming provides premium meat and wool, adding to agricultural diversity. The manure from sheep improves soil health and fertility, and the industry bolsters rural economies and sustainable land management practices.

3. EVALUATION BASED ON DISTANCE FROM AVERAGE SOLUTION

This paper introduces the EDAS (Evaluation based on Distance from Average Solution) method, a relatively new and mathematically rigorous tool for Multi-Criteria Decision Making (MCDM). It is used to rank thirteen cotton fabric samples based on four key attributes: cover, thickness, areal density, and porosity, with the aim of identifying fabrics with optimal thermal comfort properties. Sample 3 achieved the highest appraisal score of 0.9838, making it the top choice, while Sample 6, with a score of 0.0000, ranked last. The ranking results closely align with previous methods, showing high rank correlation coefficients (Rs > 0.87). Rankings generated using four hypothetical weight sets also showed strong agreement, with correlation coefficients above 0.90, and no rank reversal occurred, even when the decision-making matrix was modified. This paper introduces a picture fuzzy EDAS model, which is based on the traditional EDAS (Evaluation based on Distance from Average Solution) framework. Initially, we provide a brief overview of picture fuzzy sets (PFSs) and present the score function, accuracy function, and operational laws for picture fuzzy numbers (PFNs). Next, we integrate the traditional EDAS model for multi-criteria group decision-making (MCGDM) with PFNs. This integration enhances accuracy and effectiveness when addressing conflicting attributes. To demonstrate the applicability of this new model, we present a numerical example focused on green supplier selection. Additionally, we conduct comparisons between the EDAS model utilizing PFNs and the PFWA and PFWG aggregation operators to further highlight the advantages of our proposed method. This paper makes a modest attempt to address a research gap by investigating the effectiveness of a hybrid approach combining Design of Experiments (DOE) and the EDAS method for selecting the best materials across various engineering applications. Initially, a full factorial experimental design is established with five replications and two levels for each material selection property. Following this, a regression meta-model is developed to establish relationships between the material selection properties and the EDAS scores, highlighting the main effects as well as potential two-way and three-way interactions among these properties. The results indicate that this meta-model performs well in accurately determining the performance scores of the materials.

4. RESULT AND DISCUSSION

TABLE 1. Organic Fertilizer Composition

Nutrient	Beef/Dairy (%)	Poultry (%)	Swine (%)	Sheep (%)
Nitrogen	2.8	5.8	3.5	3.5
Phosphorus	2.5	1.2	0.5	4.8
Potassium	1.3	1.2	1.2	2.3
Magnesium	1.5	2.3	0.8	0.5
Sodium	1.3	1.2	0.5	0.2

The table 1 presents a comparison of nutrient content percentages for nitrogen, phosphorus, potassium, magnesium, and sodium in four types of animal manure: Beef/Dairy, Poultry, Swine, and Sheep. Poultry manure has the highest nitrogen content at 5.8%, while Beef/Dairy, Swine, and Sheep all share a nitrogen level of 3.5%. Regarding phosphorus, Sheep manure shows the highest percentage at 4.8%, whereas Poultry has the lowest at 1.2%. For potassium, Sheep manure ranks highest at 2.3%. Poultry also has the highest magnesium content at 2.3%, while Swine displays the lowest at 0.8%. Sodium levels are relatively low across all types, with Sheep having the least at 0.2%.

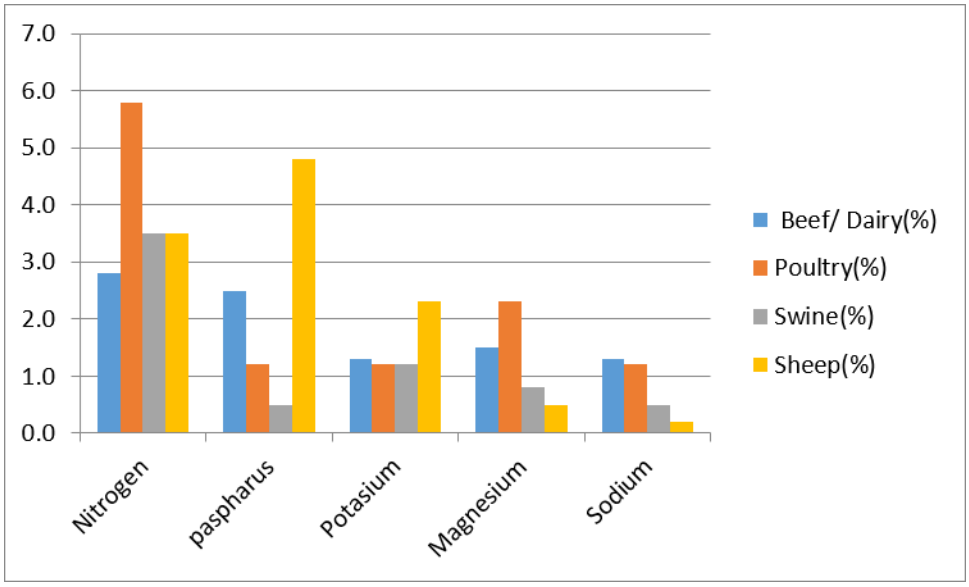


FIGURE 1. Organic fertilizer

This chart 1illustrates the nutrient composition (percentage) of nitrogen, phosphorus, potassium, magnesium, and sodium in four types of animal manure: Beef/Dairy, Poultry, Swine, and Sheep. Poultry manure contains the most nitrogen and phosphorus, while Sheep manure has the highest potassium content. Beef/Dairy manure shows a more even distribution of nutrients but lower nitrogen and phosphorus compared to Poultry. Swine manure has moderate levels across most nutrients, with nitrogen being relatively low. Sodium content is minimal in all cases, with Beef/Dairy manure having the highest amount. The variation in nutrient content impacts each manure's effectiveness as a fertilizer.

TABLE 2. Positive Distance from Average (PDA)

Nutrient	Beef/Dairy	Poultry	Swine	Sheep
Nitrogen	0.49	1.48	1.69	0.55
Phosphorus	0.33	0.00	0.00	1.12
Potassium	0.00	0.00	0.00	0.02
Magnesium	0.00	0.00	0.00	0.00
Sodium	0.00	0.00	0.00	0.00

The table 2 outlines the Positive Distance from Average (PDA) values for different nutrients, indicating how much they

surpass the average in various categories. Nitrogen holds the highest PDA values, peaking at 1.69, signifying its substantial positive influence on soil quality. Phosphorus shows variation, with a maximum value of 1.12, indicating notable positive contributions in specific conditions. Potassium exhibits very low PDA values, with a maximum of just 0.02, reflecting minimal positive effect. Both magnesium and sodium display zero PDA values across all categories, suggesting no positive deviation from the average and a limited role in improving soil health in this context.

TABLE 3. Negative Distance from Average (NDA)

Nutrient	Beef/Dairy	Poultry	Swine	Sheep
Nitrogen	0.00000	0.00000	0.00000	0.00000
Phosphorus	0.00000	0.48718	0.61538	0.00000
Potassium	0.30851	0.48718	0.07692	0.00000
Magnesium	0.20213	0.01709	0.38462	0.77876
Sodium	0.30851	0.48718	0.61538	0.91150

The table 3 presents the Negative Distance from Average (NDA) values for different nutrients, reflecting how much they fall below the average across various categories. Nitrogen shows zero values consistently, indicating no negative deviation and highlighting its stable availability in the soil. Phosphorus varies in its NDA values, peaking at 0.61538, which points to significant negative deviations under certain conditions. Potassium has moderate NDA values, with a maximum of 0.30851, suggesting some deficiencies in specific scenarios. Magnesium also varies, reaching a high of 0.77876, indicating considerable negative distance. Sodium consistently shows the highest values, indicating it often lags behind in average availability in the soil.

TABLE 4. Weight Matrix

Weight					
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25

The table 4 values given represent a consistent weighting system, with each value uniformly set at 0.25 across several rows. This signifies an equal distribution of weight assigned to various components, factors, or criteria being evaluated. Each element holds the same value, indicating that all factors are considered equally significant in the analysis or calculation. This method is commonly employed in different assessments, including scoring systems and decision-making processes, where the aim is to treat all criteria with equal importance, providing a balanced view in the overall evaluation.

TABLE 5. Weighted PDA and SP_i

Nutrient	Beef/Dairy	Poultry	Swine	Sheep	SP_i
Nitrogen	0.12234	0.36966	0.42308	0.13717	1.05224
Phosphorus	0.08245	0.00000	0.00000	0.28097	0.36342
Potassium	0.00000	0.00000	0.00000	0.00442	0.00442
Magnesium	0.00000	0.00000	0.00000	0.00000	0.00000
Sodium	0.00000	0.00000	0.00000	0.00000	0.00000

The table 5 presents the Weighted Positive Distance from Average (PDA) and Soil Potential Index (Spi) for different nutrients, highlighting their importance and potential in soil health. Nitrogen leads with the highest PDA of 1.05224, reflecting its significant positive influence on soil quality. Phosphorus demonstrates a range of values, peaking at 0.28097, indicating a moderate contribution to soil potential. In contrast, potassium shows very low PDA values, maxing out at 0.00442, signifying its limited importance. Both magnesium and sodium have zero values in all categories, indicating they lack positive impact or potential in this context.

The table 6 outlines the Weighted Negative Distance from Average (NDA) and Soil Nutrient Index (SN_i) for different

TABLE 6. Weighted NDA and SN_i

Nutrient	Beef/Dairy	Poultry	Swine	Sheep	SN_i
Nitrogen	0.00000	0.00000	0.00000	0.00000	0.00000
Phosphorus	0.00000	0.12179	0.15385	0.00000	0.27564
Potassium	0.07713	0.12179	0.01923	0.00000	0.21815
Magnesium	0.05053	0.00427	0.09615	0.19469	0.34565
Sodium	0.07713	0.12179	0.15385	0.22788	0.58064

nutrients, reflecting their relative availability and importance. Nitrogen shows zero values across all categories, indicating no negative deviation and minimal variation in availability. Phosphorus presents values ranging up to 0.27564, suggesting moderate variability and partial limitation. Potassium exhibits a maximum value of 0.21815, indicating relatively restricted availability compared to other nutrients. Magnesium varies between 0.00427 and 0.34565, showing generally low but slightly improved availability. Sodium records the highest SN_i value of 0.58064, indicating comparatively greater availability in the system than the other nutrients.

TABLE 7. Soil Potential Index (SP_i) and Soil Nutrient Index (SN_i)

Nutrient	SP_i	SN_i
Nitrogen	1.00000	1.00000
Phosphorus	0.34538	0.52528
Potassium	0.00421	0.62429
Magnesium	0.00000	0.40471
Sodium	0.00000	0.00000

The table 7 values illustrate the Soil Potential Index (SP_i) and Soil Nutrient Index (SN_i) for different nutrients, indicating their importance in soil quality and nutrient availability. Nitrogen achieves a perfect score of 1.00000 in both indices, highlighting its essential role in soil fertility. Phosphorus shows moderate values with an SP_i of 0.34538 and an SN_i of 0.52528, indicating intermediate contribution to soil nutrient status. Potassium exhibits a very low SP_i of 0.00421 but a comparatively higher SN_i of 0.62429, suggesting greater availability despite limited potential. Magnesium records 0.00000 for SP_i and 0.40471 for SN_i, while sodium remains at 0.00000 for both indices, indicating minimal contribution to soil quality.

TABLE 8. Aggregate Soil Index (AS_i)

Nutrient	AS_i
Nitrogen	1.00000
Phosphorus	0.43533
Potassium	0.31425
Magnesium	0.20236
Sodium	0.00000

The table 8provided values represent the Agricultural Significance Index (ASi) for different nutrients, showing their relative importance or abundance. Nitrogen, with the highest ASi of 1.00000, is crucial for plant growth, making it the most important nutrient. Phosphorus follows with an ASi of 0.43533, playing a key role in energy transfer and root development, though less vital than nitrogen. Potassium, at 0.31425, aids in water regulation and enzyme activation. Magnesium, with an ASi of 0.20236, supports photosynthesis but is less prominent. Sodium, with an ASi of 0.00000, is insignificant in this particular context.

The table 9 indicates the relative importance or abundance of various nutrients, with nitrogen at the top (rank 1) and sodium at the bottom (rank 5). Nitrogen, crucial for plant growth and development, is typically the highest priority in agriculture and environmental management. Phosphorus, ranked second, is essential for energy transfer and root development. Potassium, in third place, supports water regulation and enzyme function. Magnesium, ranked fourth, is key for photosynthesis, as it's central to chlorophyll. Sodium, ranked last, is less vital compared to the others, although it is needed in small quantities for certain plants.

TABLE 9. Ranking of Soil Nutrients

Nutrient	Rank
Nitrogen	1
Phosphorus	2
Potassium	3
Magnesium	4
Sodium	5

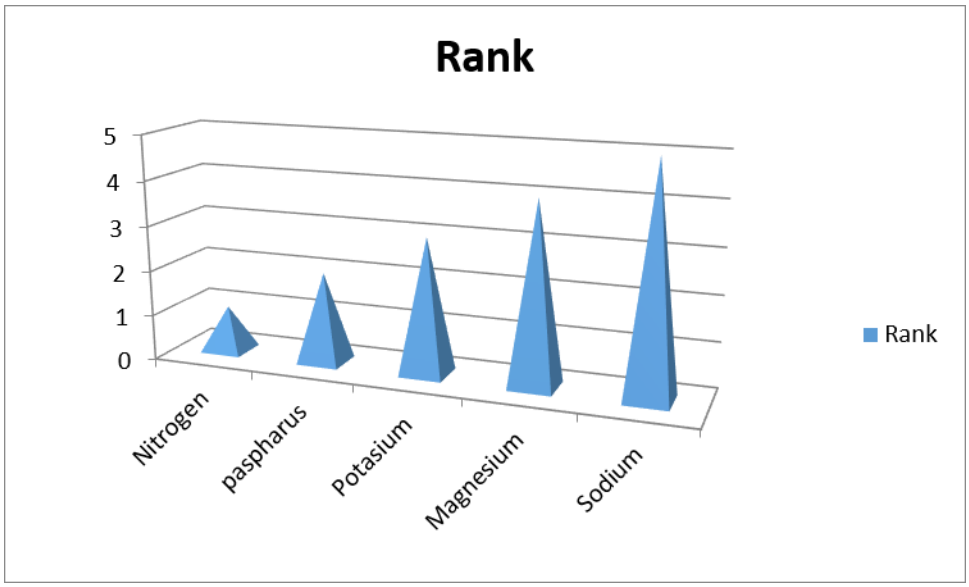


FIGURE 2. Rank

The figure 2 ranking reflects the relative significance or abundance of different nutrients, with nitrogen ranked highest (1) and sodium lowest (5). Nitrogen, essential for plant growth and development, is usually the top priority in agriculture and environmental management. Phosphorus, in second place, plays a vital role in energy transfer and root growth. Potassium, ranked third, aids in water regulation and enzyme activity. Magnesium, in fourth place, is crucial for photosynthesis as it's a core component of chlorophyll. Sodium, ranked last, is less important than the others, although small amounts are required by certain plants.

5. CONCLUSION

Organic fertilizers are essential for promoting sustainable agriculture and gardening, providing various advantages that enhance soil health, plant development, and environmental sustainability. Unlike synthetic fertilizers, which can harm soil quality and contribute to water pollution, organic fertilizers work with the natural processes of the soil, fostering a healthier ecosystem. This conclusion emphasizes the importance of organic fertilizers, their benefits, and their role in promoting sustainable farming practices. A key advantage of organic fertilizers is their ability to enhance soil fertility and structure. They supply vital nutrients such as nitrogen, phosphorus, potassium, and essential micronutrients that support plant health. Organic fertilizers release these nutrients gradually, ensuring a continuous supply for plants while minimizing the risk of nutrient leaching into water sources. This gradual release improves nutrient uptake efficiency, allowing plants to utilize what they need without the excess often seen with synthetic fertilizers. Beyond nutrient provision, organic fertilizers also boost soil structure by increasing its organic matter content. This improved structure enhances water retention, aeration, and drainage, creating optimal conditions for root growth. Healthy soil teems with microorganisms that play a crucial role in nutrient cycling and disease resistance. Organic fertilizers promote these beneficial microbial populations, nurturing a vibrant soil ecosystem that supports plant vitality and resilience. The adoption of organic fertilizers is vital for sustainable agricultural practices. With rising global food production demands, the environmental implications of synthetic fertilizers

are increasingly alarming.

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