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Soil Fertility Assessment of Sainamaina Municipality, Rupandehi, Nepal

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Abstract

Soil fertility assessment is a very fundamental task for farmers and agricultural planner to adopt appropriate fertility management practice, to recommend applying lacking fertilizers, to make fertility based agricultural plan and produce large amount of crops in their land. This study assesses soil fertility status of Sainamaina Municipality, ward no. 5-9, Rupandehi district based on soil sample data collected from field. Soil test-based fertility assessment, calculation of overall fertility of area using fertility index and preparation of soil fertility map is carried out. As soil fertility, status of total nitrogen (TN), phosphorus (P_2O_5), potassium (K), organic matter (OM) and soil pH are measured. As a result, status of TN, (K_2O), and OM is found low, status of (P_2O_5) is found high and soil pH is found in rang of very strongly acidic to slightly alkaline.

Keywords: Soil fertility, fertility assessment, nutrient index, organic matter

Introduction

Soils, a non-renewable natural resource, are the basis from which world's most of foods produced. Soil is one of the most important natural resources for agriculture production (Tripathi, 2019). Pant roots resides within this material and extract water and nutrients (Jensen, 2010). Through the long period of time, physical processes break down the rock into smaller and smaller pieces and chemical processes alter the mineral composition of original rock producing new minerals (Strahler, 2012). Soil is complex system in itself. Only one or two factors are not sufficient for soil. For soil formation, five forming factors climate, vegetation, topography, time, and parent material are responsible. Interaction of these five factors is responsible for soil formation (Lal & Shukla, 2005). Lack of any one of above-mentioned factor causes insufficiency for complete soil formation.

Climate and vegetation are taken as active factors for soil genesis and parent material, time and topography are passive factor of soil formation (Schaetzl & Anderson, 2005). It takes very long time for formation of matured soil. It takes 500 years of time to form one-inch soil (Foth, 1990).

Soil fertility is the status or the inherent capacity of the soil for supplying nutrients to plants in an adequate amount for growth development flowering and fruiting. Soil fertility, in other words refers to status of a soil with respect to its ability to supply elements essential for plant growth without a toxic concentration of any element (Foth, 1990). The production of crop is determined by its fertility. High fertile soil produces high crops and low fertile produces low. Soil fertility is required differently by different crops and plant with respected to proportion of available nutrient. Soil fertility is composition of various nutrients in appropriate quantity and quality. Availability of nutrients in soil may be different with respect to time and space.

Soil fertility assessment is first step for sustainable agricultural development. For effective soil fertility and nutrient management, soil fertility assessment is first and basic decision-making step (Iftikar et al., 2010). Soil fertility assessment includes soil sampling testing and estimating crop nutrients. Among various methods of soil fertility assessment soil test- based method is very commonly used method for agricultural planning and decision making for fertilizer recommendation (Paudel, 2018). Hill to Tarai migration is increasing day to day in Nepal. As a result, agricultural land of Tarai region is decreasing day to day because of town planning of agricultural land agricultural land of hill region is abandoned. To feed increasing population and to produce maximum food and vegetable from limited land resource according to its suitability soil fertility assessment is very important task. But there is limited study on the different part if country including Rupandehi District.

Methods and Materials

In an agro-based country like Nepal soil and soil fertility management is very important. Most of the people of Nepal depend upon agriculture and soil is directly related to agriculture. The quality and nutrient content of soil determines the soil productivity. For this study ward no. 5, 6, 7, 8 and 9 of Sainamaina Municipality Rupandehi district is selected (Figure 1). This area is selected for study because most of the people of this area are engaged in agriculture. Because of rapid urbanization agricultural land is decreasing day to day but peoples' dependency on food will never decreased. In this critical situation people must be fed from agricultural production. To feed increasing people from limited agricultural land and proper management of soil fertility is urgently needed. The study area lies in Tarai region where in-migration from hilly region has been taking place. Because of in-migration from hilly region Agricultural land of Tarai region is decreasing and agricultural land of hilly region is abandoned day to day. This study aims to assess the soil fertility status of study area for proper management of soil and to get optimum benefit from soil.

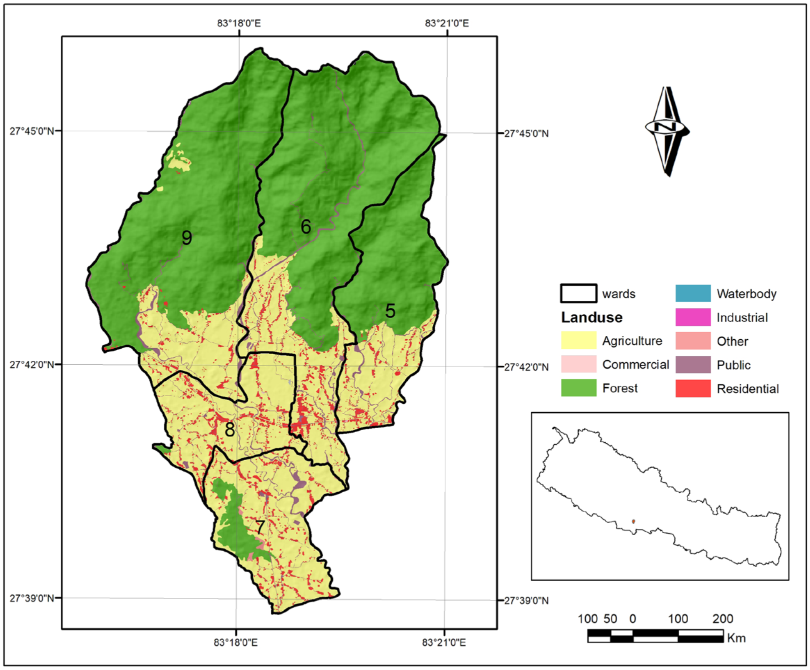

Figure 1. Study area

Present study was conducted based on primary and secondary data. Land system map and land capability map prepared by land resource mapping project (LRMP), land use map prepared by National Land Use Project (NLUP) and topographic map prepared by Survey Department, Government of Nepal were used as secondary data to make polygon for soil sampling from study area. Soil polygon were made by intersecting land system and land capability map using Arc-gis 10.5 software and agricultural land use is selected for study. Each sample represents the different land system and different land capability under agricultural land use. Soil samples were taken from depth of 0-20c m then tested in soil lab of central department of Geography, Tribhuvan University. The major parameters are soil pH, total nitrogen (TN), total soil organic matter (SOM), available phosphorus (P_2O_5) and available potassium (K_2O) of soil fertility of study area. Soil pH was extracted using pH meter. Soil Organic Matter (SOM) in soil is tested by Black and Wackley method and presented in percent. The Kjeldhal method was used to extract total nitrogen (TN) available in soil and presented in percent. To detect available Phosphorus (P_2O_5) sodium bicarbonate ($NaHCO_3$) at pH 8.5 solution was used as Phosphorus extractants for the soils. It is presented as kg/ha. The potassium content in the leaching was extracted with 1N ammonium acetate at pH 7.0. The soil extract was measured by Flame photometry. It is presented as kg/ha. For the rating of nutrient status rating scale prepared by Department of Agriculture 1999 is used and to calculate the single value of soil fertility Parker's soil fertility index is used.

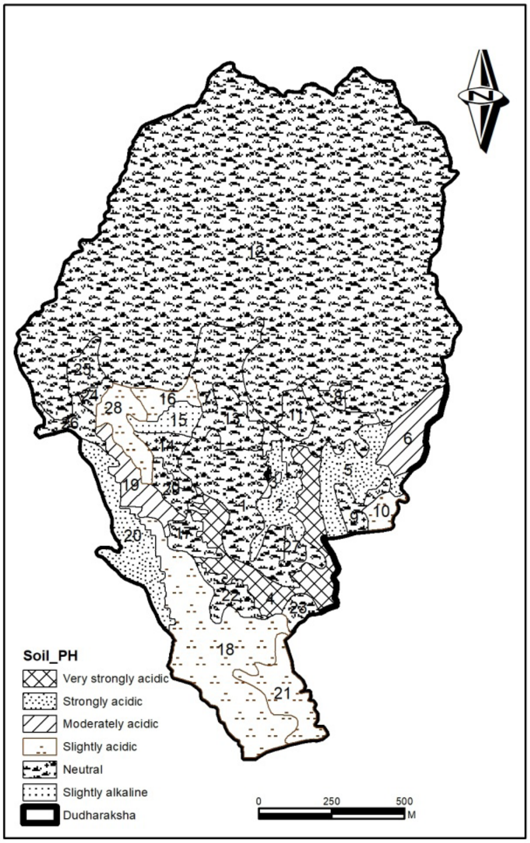

Figure 2. pH map

Results and Discussion

Soil pH

Availability of Soil pH influences the solubility of nutrients. It also affects the activity of micro-organisms responsible for breaking down organic matter and most chemical transformations in the soil. Soil pH thus affects the availability of several plant nutrients. A pH range of 6 to 7 is most favorable for plant growth and development because most plant nutrients are readily available in this range. However, some plants have soil pH requirements above or below this range. The pH of study area found as very strongly acidic to slightly alkaline (Table 1).

Table 1. Soil nutrient status of study area

Nutrients	Number	Minimum	Maximum	Mean	Std. Deviation	Variance
pH	29	5.00	7.70	6.50	0.67	0.45
N	29	0.05	0.16	0.091	0.02	0.001
P_2O_5	29	1.06	251.06	71.64	53.34	2845.48
K_2O	29	1.38	107.46	40.32	29.13	848.61
OM	29	0.64	3.49	1.56	0.59	0.35

Source: Laboratory test

Of the total 29 polygon, polygon no.4 is found as very strongly acidic, polygon 2, 5, and 20 are found as strongly acidic, polygon 3,6 and 19 are found as moderately acidic, polygon 10, 28, 21, 16 are 18 found as slightly acidic, polygon 17,8, 26, 25, 14,19, 27, 27, 12, 24, 7,1,13, 22, 29, 11 and 23 are found as neutral in pH and polygon 15 is found as slightly alkaline (Figure 2).

Soil organic matter (SOM)

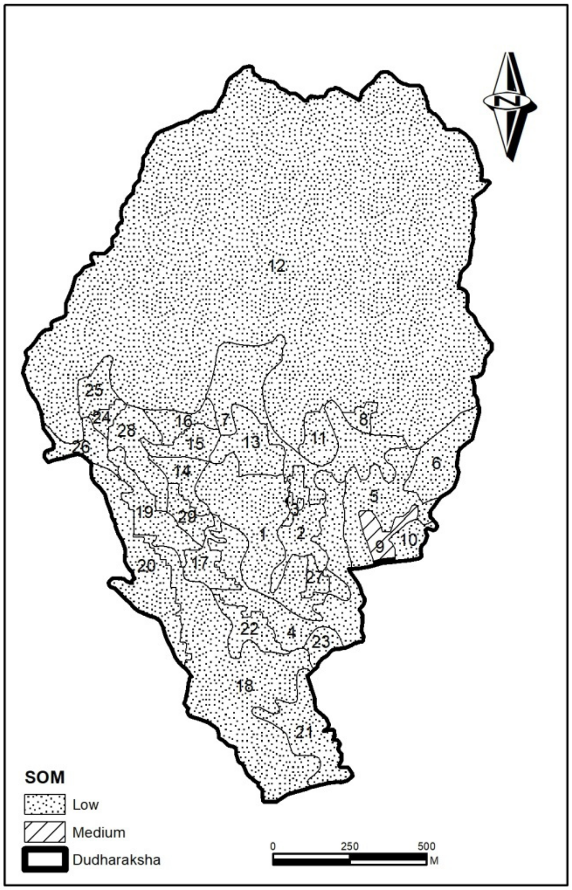

Figure 3. Soil organic matter area

Soil Organic matter (SOM) refers to any material produced and originated from living organism which contain 60-90 % soil moisture, hydrogen (H), nitrogen (N), Sulphur (S) phosphorus (P) potassium (K) calcium (Ca) and magnesium in different amount (FAO 2005). Present living organism and previously living organism decaying in their different rate available in soil is known as organic matter. Organic matter is vital soil properties for agriculture and essential macronutrient for increase soil fertility required for plant growth and development that is extremely associated with soil physical, chemical, and biological processes (Mandal, 2016). Soil organic matter plays double role in soil first makes better condition of soil physical chemical and biological properties of soil and SOM itself plays role of fertility for plants (Camp, et al., 2004). The range of organic matter ranges from 0.64 to 3.49 with mean value of 1.56 (Table 1) which varies very low to medium. Because of its role in physical chemical and biological process soil organic matter can be considered as a pivotal component of the soil. Organic matter is the main source of N, P and S for plant growth (Acquaye, 1990). SOM is an indicator of soil fertility, aggregate stability and erosion. In addition, SOM contributes to enhance soil water storage and maintenance of pH. Farmers should therefore be encouraged to return as much as residue as possible to soil in addition to application of manure and compost. In the study area, only one polygon, polygon no. 9, soil organic matter content is found as medium class and remaining all 28 polygons have low (SOM) content (Figure 3). To improve soil organic matter application of organic fertilizer like animal manure and green manure are needed to apply.

Total Nitrogen (TN)

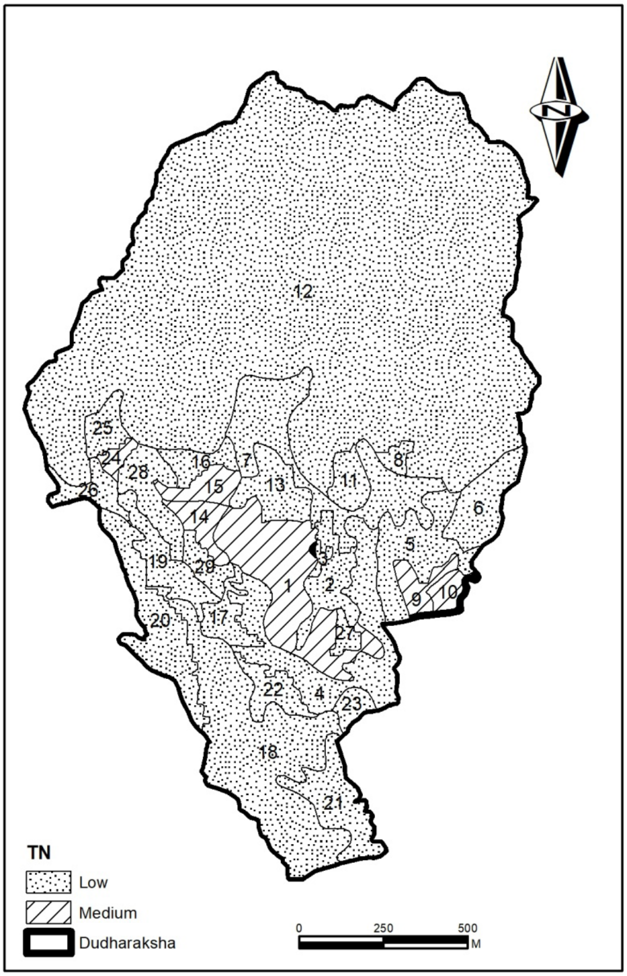

Figure 4. Soil nitrogen map

Nitrogen (TN) is mineral nutrient which is very important for optimum crop yields (Latt et al., 2009). Nitrogen is the basic nutrient that helps in seed formation and also helps the food and feed value of crops. For crop growth crop quality and better yield nitrogen usually has a specific impact. The total nitrogen content varies from 0.05% to 0.16 % with the mean value of 0.091 % (Table 1). Overall results showed that the nitrogen content was low to medium. Nitrogen content of polygon 22, 20, 5, 26, 28, 23, 27, 6, 8, 3,12,18, 7, 11, 13, 16,29,25, and 17 was low and polygon 21, 2,19 24,10,15,14,1 and 9 has medium nitrogen content Figure 4) which justify that recommended dose of nitrogen is required to apply in the field for increasing production of crops. The low nitrogen content in the study area may be possibly due to low organic matter content in soils, crop removal and due to high temperature, which facilitate faster degradation and removable of organic matter leading nitrogen deficiency. As SOM increases, available N, P K as well as some micronutrients also increase.

Phosphorus (P_2O_5)

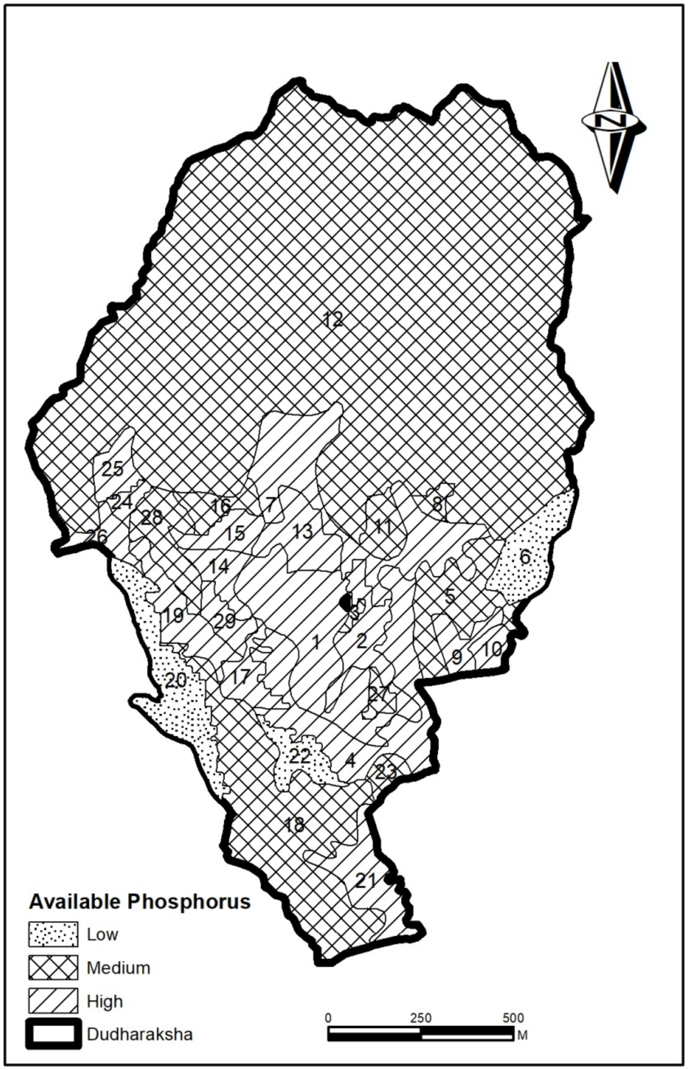

Figure 5. Soil phosphorus map

Phosphorus (P_2O_5) is essential element to all living beings on earth. Soil phosphorus is primary nutrient for plant. Phosphorus plays great role for fundamental process of photosynthesis, flowering fruiting, maturation, root growth and cell division (Well & Brady, 2017). Phosphorus is one of the important primary elements essential for plant growth and development. It is particularly helpful in the production of legumes, as it increases the activity of nodule bacteria, which fix nitrogen in the soil. The available phosphorus content in the study area varies from 1.06kg/ha to 251kg/ha with the mean value of 71.64 kg/ha (Table 1). Phosphorus content in polygon no 3, 5, 6, 8, 16, 20, 22, 23, 27 and 28are low, polygon no. 1, 2, 4, 7, 10, 11, 12, 13, 17, 18, 19, 21, 24, 25, 26 and 29 are medium in rank and high in polygon no. 9, 14 and 15 (Figure 5). Generally, phosphorus deficiency causes the plant in dark-green but the lower leaves may turn yellow and dry up. Soils of the study site containing medium level of phosphorus may be possibly due to application of phosphoric fertilizer to crops by farmers.

Available Potassium (K_2O)

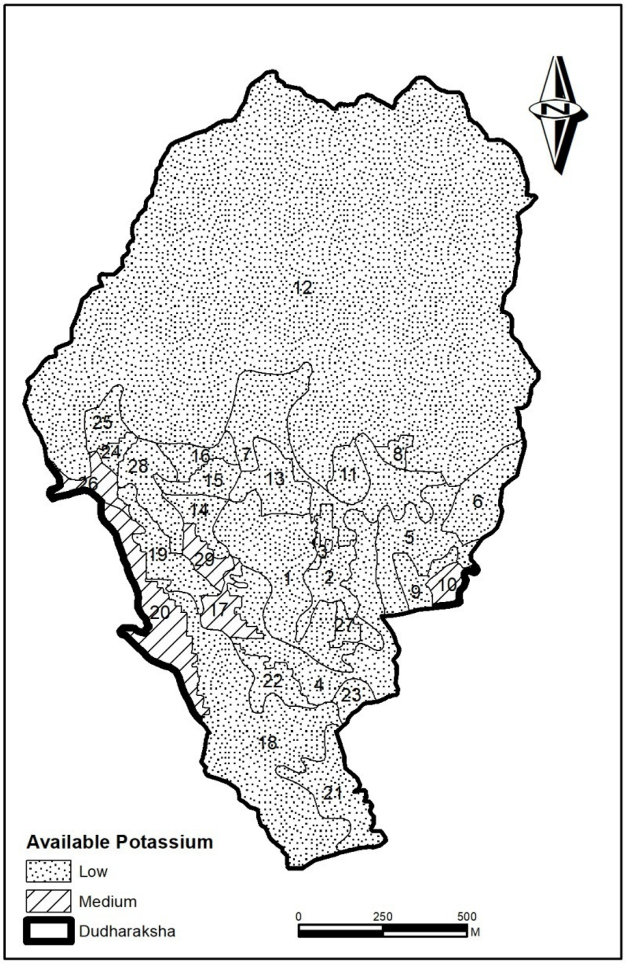

Figure 6. Soil potassium map

There is vital role of potassium (K_2O) to many plant processes and its function (Prajapati and Modi, 2012). Potassium is the element which is involved in physiological processes of plants with the activation of large number of enzymes. It plays a vital role in the formation or synthesis of amino acids and proteins from ammonium ions which are absorbed from the soil. Enzyme activation, stomatal activity, photosynthesis, transportation of sugar, water and nutrient transportation, protein synthesis and starch synthesis are function of potassium in a plant. Thus, sufficient amount of potassium (K_2O) is needed for well growth of plant and sufficient production of crop. The available potassium ranged from 1.38 kg/ha to 107.46 kg/ha with mean value of 40.32 kg/ha (Table 1).

In polygon no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 21, 22, 13, 24, 25, 27 and 29 of study area potassium status was found low and remaining five polygon,

polygon no. 10,17,20,26, and 29 have medium potassium level (Figure 6) indicating that the amount of potassium is decreasing in Tarai soils, which justify that recommended dose of potassium should be reviewed for increasing production of crops. Deficiency of potassium causes the margins of leaves turn brownish and dry up. The stem remains slender. Low available potassium signifies higher leaching as evidenced by low base saturation in these soils which may be due to high rainfall in those areas.

Calculation of fertility index

Soil fertility is ability of soil to supply nutrients to crops and it has been drastically affected by human activities (Biet, et al., 2009). To improve sustainable land use management and achieve economic goal through agricultural yield soil fertility index is very useful indicator (Shang et. al., 2014). The single value of each nutrient of whole study area is necessary to compare with another area. The overall status of soil fertility taken from calculation of fertility index helps to make land use plan and farming policy by policy maker and adopt suitable farming system according to land suitability. The calculation of nutrient index of study area from the data status available phosphorus (P_2O_5) is found high and status of organic matter (OM), total nitrogen (TN) and available potassium (K_2O) is found low (Table 2).

Table 2. Soil fertility status

Soil parameters	**Distribution of sample calculated**				**Reference**
Nutrient Index (N.I) = (NL*1 + NM*2+NH8*3)/NT					
	Low	Medium	High	Index Value	
Organic Matter (OM)	28	1	0	1.03	Low
Total Nitrogen (N)	20	9	0	1.31	Low
Available Potassium (K_2O)	24	5	0	1.17	Low
Available Phosphorus(P_2O_5)	3	7	19	2.55	High

Here, NL Number of nutrient in low status, NM= Number of nutrient in medium status and NH = Number of nutrient in high status as rated by DoA/STSS, 1999

Conclusion

In the study area soil pH is found in range of very strongly acidic to slightly alkaline. In areas where soil pH is found very strongly acidic to slightly acidic, application of agricultural lime is needed to make soil pH better. Soil organic matter is found low except in one polygon. To make better soil in terms of organic matter, continuous use of organic matter specially, green manure and animal manure is needed. Total nitrogen available in soil is low. The application of nitrogen in farmland is required. Available phosphorus is found high in study area. Available potassium found in soil is low. After the calculation of fertility index, only available phosphorus is found high and soil organic matter total nitrogen and available potassium are found low.

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