FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Mind the (nutrient supply) gap:

An assessment of demand and supply limitations for Nitrogen, Phosphorus and Potassium for major crops in Nepal

Supported by — CSISA Partners — Aligned with

ABOUT THIS REPORT

This work is supported by the USAID/Nepal-funded Cereal Systems Initiative for South Asia (CSISA) 'Building food system resilience to global supply chain and climate shocks in Nepal' Activity supported by USAID/Nepal. CSISA aims to enhance the adoption of resource-conserving and climate-resilient technologies while improving farmers' access to market information and enterprise development, particularly for women farmers through modern innovations and entrepreneurial skills. Working in synergy with regional and national efforts, CSISA collaborates with various public, civil society, and private-sector partners to promote widespread adoption of practices that increase yields with reduced water, labor, and input costs. The initiative supports the integration of innovations into government programs, generates and disseminates knowledge on climate-resilient cropping systems, improves the policy environment for sustainable intensification technologies, and builds strategic partnerships to sustain the benefits of increased cereal system productivity. The project is led by CIMMYT and implemented jointly with IFPRI, IRRI, and IWMI, with support from the Institute for Integrated Development Studies (IIDS) and International Development Enterprises (iDE).

Supported by USAID/Nepal, the Nepal Seed and Fertilizer (NSAF) project and Nepal Agricultural research Council (NARC) also supported this effort. NSAF facilitates sustainable increases in national crop productivity, income, and household food and nutrition security across 20 districts. NSAF encourages the use of improved seeds and integrated soil fertility management technologies, alongside effective extension services that utilize digital and information communication technologies. The project enhances the availability of technologies to improve productivity in crops such as cauliflower, lentils, maize, onions, rice, and tomatoes. Additionally, it will strengthen competitive seed and fertilizer systems, significantly expanding seed production, marketing, and distribution by enhancing the capacity of both public and private sectors within seed and fertilizer value chains.

This work is also strategically aligned with the CGIAR Regional Integrated Initiative Transforming Agrifood Systems in South Asia (TAFSSA). Working across South Asia, this Initiative aims to deliver a coordinated program of research and engagement across the food production–to–consumption continuum to support equitable access to sustainable healthy diets, improve farmer livelihoods and resilience, and conserve land, air and groundwater resources. The authors would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund.

Suggested citation: Chakraborty, D., Sherpa, S.R., Koirala, P., Baral, B.R., Karki, S., Sapkota, S., Gathala, M., Krupnik, T.J. (2024). Mind the (nutrient supply) gap: An assessment of demand and supply limitations for Nitrogen, Phosphorus and Potassium for major crops in Nepal. The Cereal Systems Initiative for South Asia (CSISA), Nepal Seed and Fertilizer (NSAF) Project, and Transforming Agrifood Systems in South Asia (TAFSSA). Kathmandu, Nepal.

Cover photo: Mitra Rawat applying urea fertilizer to maize in Bhamake, Dang. Photo: P. Lowe

BACKGROUND

For decades, mineral fertilizers have served as a crucial means to counter soil nutrient depletion and enhance crop productivity. Long-term studies have confirmed that fertilizer application has contributed to at least a 50 percent increase in crop yield in the 20th century (Mikkelsen, 2024). The efficient use of fertilizers, however, varies widely between and within different countries, and among different crops. Despite a 212 percent increase in synthetic fertilizer use per hectare of arable land between 2000 and 2021 in Nepal, the average rate of use remains one of the lowest in South Asia, at 97 kg/ha, compared to Bangladesh (384 kg/ha), India (193 kg/ha), and Pakistan (157 kg/ha), as well as the global average of 140 kg/ha (World Bank, 2024).

The average rate of growth in rice productivity in Nepal, which supplies more than half of the country's calorie needs, has been around 0.16% over the last 50 years, significantly lower than the rate of population growth (IRRI, 2024). Moreover, the average productivity of maize and wheat, the second and third major cereals in Nepal, is also very low at 3.0 and 2.3 MT/ha, respectively. Between 2000 and 2024, Nepal's population grew by 27 percent, and during the same period, cereal production increased by 64 percent, rising from 7.1 to 11.7 million tons; yet per capita availability is still low at 380 kg (United Nations, 2024; World Bank, 2024). Consequently, the relationship among population growth, cereal production, and fertilizer consumption is at a critical point in Nepal. Addressing this nexus will be a key policy and market issue essential for improving food security and agricultural sustainability in the country.

Other than imperfectly functioning markets and fertilizer distribution systems, the low use of synthetic fertilizers is also linked to a lack of farmers' awareness of improved fertilizer management practices (Gautam et al., 2022). Crops use nitrogen for biomass growth and grain development, phosphorus for root systems, and potassium to strengthen cell walls and regulate water uptake, all contributing to yield. Yet estimates are that current supplies of N, P_2O_5, and K_2O fertilizers only meet roughly 60 percent of the chemical fertilizers' demand in Nepal at a national level (Gautam et al., 2022). Despite significant government investment in fertilizer subsidies through supply and distribution programs, the expected improvements in agricultural productivity have not been realized (Panta, 2018; Krupnik et al., 2022). Supply chains for chemical fertilizers in Nepal face several key challenges, including those related to policies, ineffective regulation, lack of funds, poor distribution and storage infrastructure, and informal trading from India. Addressing these challenges will be crucial for enhancing fertilizer availability and improving overall agricultural productivity in Nepal (Panta, 2018). Despite significant government spending on fertilizer subsidies[1], the timely and assured supply of quality chemical fertilizers has not been guaranteed (Panta, 2018).

A revised and thorough assessment of fertilizer demand is key for accurately projecting the total budget required for procurement, ensuring the timely supply of fertilizers for specific seasons and crops, estimating the necessary volume of buffer stock, and enhancing distribution efficiency. Similarly, such an assessment can assist in efforts to strengthen the private production and/or

[1] The government of Nepal (GoN) has allocated NPR 27.9 billion (USD 208.4 million) for fertilizer subsidies in its budget for Fiscal Year (FYI 2024/25 (Nepali FY 2081/82), which account for 48.7 percent of the total budget allocated for the Ministry of Agriculture and Livestock Development (MoALD) (Palikhe et al., 2024).

import and supply of fertilizers in Nepal. Reports of fertilizer shortages from farmers nationwide, particularly during primary cropping seasons, underscore the inadequacy of subsidized fertilizer supply to meet demand (Panta, 2018). Currently, Nepal lacks a systematic and reliable method for estimating actual fertilizer demand at both national and district levels. Given the country's reliance on subsidies for fertilizer import, supply, and distribution, accurate estimation of fertilizer demand across diverse regions and crops is imperative for effective import and distribution planning. Fertilizer requirements for crops are influenced by a range of factors, including soil type, nutrient content, previous cropping systems, growing seasons, crop species, climatic conditions, and irrigation methods. Regrettably, precise data on fertilizer demand in Nepal is currently unavailable to the public. Addressing this gap and providing reliable information is crucial for developing effective policies and strategies to enhance fertilizer availability and optimize agricultural productivity.

Currently each of Nepal's 267 municipal governments forecasts fertilizer demand on an annual basis of which a provincial committee allocates fertilizer quota for each municipality (Gautam et al., 2022). Municipalities estimate fertilizer demand based on the anticipated cultivated land area of specific crops and rough estimates of supplies needed to meet production targets. This standard and conventional approach could benefit from increased nuance, particularly regarding fertilizer recovery efficiencies, indigenous soil nutrient-supplying capacity, and information on potentially attainable yield in addition to average levels of productivity. In this context, there is a need to develop a fertilizer demand forecasting system based on scientific parameters (Gautam et al., 2022). Such a system will enable more accurate predictions of fertilizer needs, ultimately enhancing agricultural productivity and sustainability. Additionally, it will help target governmental expenditures on fertilizer acquisition and supply more appropriately, while enabling the private sector to identify key geographies for fertilizer sales (Panta & Parajulee, 2021).

In this context, this study fills this gap by developing a reliable, data-driven method for estimating fertilizer demand at both national and district levels from an agronomic standpoint to address critical challenges in Nepal's fertilizer supply and distribution system. This study seeks to provide a scientifically grounded approach to estimate fertilizer demand, which will better inform procurement, distribution planning, and policy decisions. By doing so, it offers a more effective way to meet fertilizer demand, thereby enhancing crop productivity and addressing broader population and food security challenges in Nepal.

OBJECTIVES

The demand and supply gaps of key fertilizers (i.e., N, P_2O_5, and K_2O) were analyzed for five major crops: rice, maize, wheat, potato, and tomato, in Nepal. Specifically, this study (i) estimates the demand for fertilizers across 20 Terai districts that comprise the western portion of Nepal's 'Feed the Future' (FtF) Zone of Influence (ZoI; Figure 1) supported by USAID, based on factors such as cultivated land area, crop species and seasons, soil indigenous nutrient status, and irrigation availability, and (ii) assesses the gap between current supply and estimated demand for N, P_2O_5, and K_2O fertilizers.

CONCEPTUAL APPROACH

A scientifically robust ex ante analysis was performed to evaluate the current demand for macronutrients N, P_2O_5, and K_2O fertilizers for three primary cereals (rice, maize, and wheat) and two major vegetable crops (potato and tomato) in 20 western FtF districts of Nepal (Figure 1). The analysis utilized a mixed combination of primary and secondary data to estimate crop cultivated area, yield, and nutrient use efficiency targets. This approach supports the identification of spatial patterns in fertilizer demand and deficits for each district, focusing on the selected crops based on their relative area in each district.

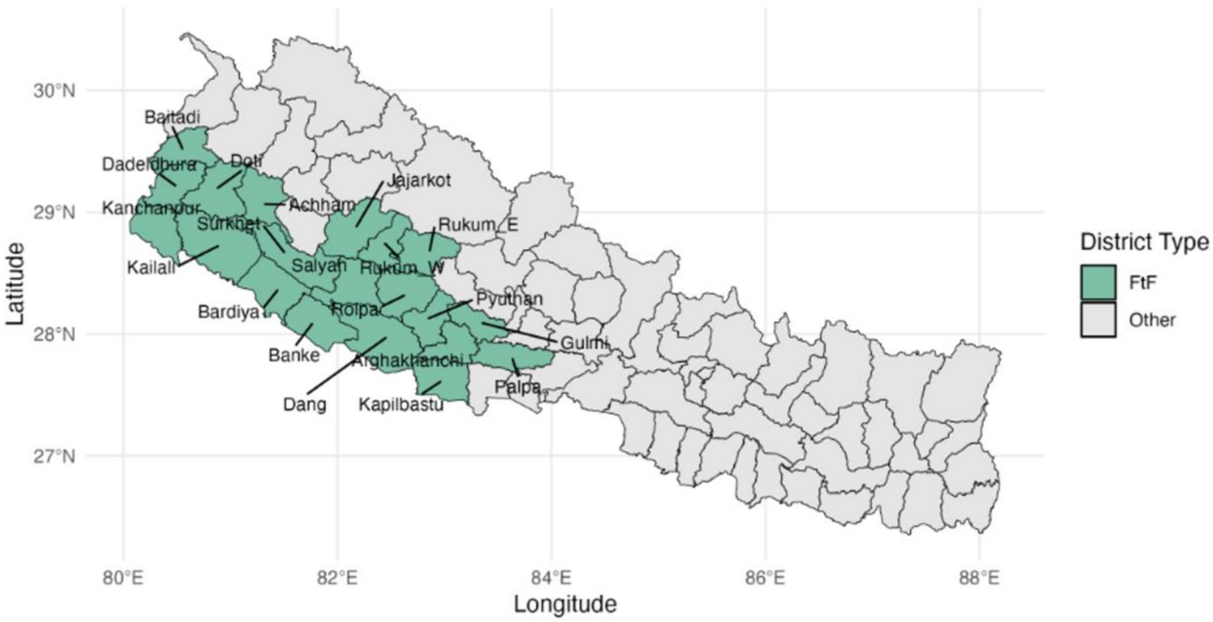

Figure 1. Twenty selected western Feed the Future (FtF) districts used in the analysis.

The analysis of crop nutrient demand utilized a partial factor productivity (yield per unit of fertilizer nutrient applied) based nutrient use efficiency approach. NUE estimates from leading crop yield-producing countries worldwide for selected crops were integrated with district-wise yields as reported by the Government of Nepal in 2021-22. Fertilizer demand for each crop was determined by accounting for soil indigenous nutrient supplying capacity ratings derived from Nepal's Digital Soil map and utilizing nutrient supply multiplier values. Fertilizer demand for a district was estimated by considering the cultivated area under each crop. Finally, the fertilizer deficit for each of 20 districts was calculated by comparing the calculated fertilizer demand with the fertilizer sales data for each respective district.

METHODOLOGY

Approach:: This study employed a stepwise approach to assess fertilizer needs, integrating crop nutrient demand, fertilizer requirements, and district-specific factors such as crop yield and nutrient use efficiency (NUE). NUE values were extracted from FAO datasets and reviewed literature improving progress towards a more comprehensive understanding of nutrient utilization in the crops studied. The following approach was followed to calculate the fertilizer deficit for a district:

Step 1: Determine Crop Nutrient Demand (A)

The total nutrient demand of the crop (metric tons, or MT/ha) was calculated based on the average yield (MT/ha) of a district and the nutrient use efficiency (kg yield/kg nutrient supplied, percent) target of the crop (Equation 1).

$$A = \frac{\text{District average crop yield (MT/ha)}}{\text{nutrient use efficiency target}} \tag{1}$$

The nutrient use efficiency target helps determine what quantity of a particular nutrient is required to produce a given amount of crop yield.

Step 2: Calculate Crop Fertilizer Demand (B)

A native soil nutrient supply map was used to classify the FtF districts into different nutrient supply rating categories. A soil nutrient supply multiplier was applied to calculate crop fertilizer demand (MT) for each district following Equation 2. The multiplier was determined by considering location-specific NPK recommendations from the Nepal Agricultural Research Council (NARC) using soil textural characteristics (NSSRC, 2023).

$$B = A \times \text{Soil nutrient supply multiplier} \tag{2}$$

This multiplier accounts for variation in nutrient availability due to soil texture, which influences indigenous soil nutrient supply .

Step 3. Compute District Fertilizer Demand (C)

The step detailed in Equation 3 scales up the individual crop fertilizer demand to the entire district's crop area, measured in hectares to identify the total fertilizer demand for each nutrient considered in MT for the district.

$$C = A \times \text{District crop area (ha)} \tag{3}$$

4. Calculate District Fertilizer Deficit (D)

Finally, total district fertilizer demand (C) was compared with data on actual fertilizer sales (MT) for a district to determine the deficit (or surplus) (MT) for each nutrient considered (Equation 4). Here, a positive “D” score indicates a surplus, while a negative “D” indicates a deficit.

$$D = \text{District fertlizer sales (MT)} - C \tag{4}$$

Data sources: The study utilizes data from multiple sources to analyze crop production and soil nutrient levels in Nepal. Information on crop area and yield for key crops such as rice, wheat, maize, potato, and tomato were obtained from the Statistical Information on Nepalese Agriculture 2021/22, published by the Government of Nepal (MoALD, 2022). This report provided district-level statistics on crop yields and areas under cultivation that were used to determine potential fertilizer demand. Data on irrigated area by season were sourced from the National Sample Census of Agriculture, Nepal 2021/2022 (MOALD, 2022). Understanding the extent of irrigation is essential for evaluating fertilizer requirements. This is because irrigation tends to result in higher crop productivity, and hence nutrient demand by the crop. Additionally, indigenous soil nutrient supply data for nitrogen, phosphorus, and potassium were accessed through the National Soil Science Research Center's digital soil map (NARC, 2024). This approach allowed for adjustments in fertilizer demand calculations by accounting for the contribution of nutrients supplied directly by the soil rather than by fertilizer alone. A summary of key data sources is provided below.

Cropped area and production: Cropped area and yield for rice, wheat, maize, potato, and tomato data (Table 1) were obtained for 2021-2022 from MoALD (2022).

Table 1. The area of cultivation (ha) and yield (MT) of rice, wheat, maize, potato and tomato in the FtF districts in 2021-2022.

District	Area (ha x 100)					Yield (MT)				
	Rice	Wheat	Maize	Potato	Tomato	Rice	Wheat	Maize	Potato	Tomato
Achham	150.0	147.3	66.9	10.1	0.6	2.7	1.7	3.1	14.5	9.3
Arghakhanchi	71.6	73.4	169.6	7.9	0.1	3.1	2.7	3.2	16.0	20.9
Baitadi	72.2	154.0	108.6	12.5	1.1	2.5	1.6	3.0	16.5	15.0
Banke	339.0	235.0	195.5	30.0	5.2	2.3	3.4	3.2	16.9	19.5
Bardiya	495.6	235.0	53.5	42.6	5.3	2.9	3.4	3.7	16.4	11.3
Dadeldhura	58.0	87.4	38.1	14.4	1.7	3.5	2.7	3.0	17.6	16.5
Dang	351.1	126.9	249.0	24.8	7.2	3.7	3.1	3.1	16.0	18.3
Doti	96.3	143.0	40.0	19.5	3.5	2.6	2.0	3.0	14.3	11.0
Gulmi	81.9	65.2	224.5	8.4	1.2	3.0	3.0	3.0	17.0	20.0
Jajarkot	26.5	194.3	105.0	16.3	0.4	3.5	2.5	3.3	15.3	9.5
Kailali	723.8	349.4	61.3	48.6	4.8	2.5	3.6	3.5	17.5	20.6
Kanchanpur	487.5	313.6	32.5	18.7	6.1	3.8	3.3	3.6	16.5	14.3
Kapilabastu	662.6	262.9	13.3	25.9	1.8	3.2	3.7	3.3	15.1	20.0
Palpa	77.8	57.9	216.4	8.0	1.8	3.8	2.4	2.6	15.1	24.1
Pyuthan	60.3	86.9	121.6	16.2	1.0	3.1	2.9	2.9	15.7	10.4
Rolpa	44.1	86.0	123.4	13.5	4.1	2.6	2.8	3.1	16.5	10.4
Rukum east	17.2	32.7	50.4	42.5	0.1	2.6	2.7	2.9	16.5	14.3
Rukum west	17.6	93.9	83.5	4.1	0.2	2.8	2.4	2.8	15.5	12.2
Salyan	67.6	132.2	193.4	17.8	2.9	4.1	3.2	3.1	18.2	11.0
Surkhet	128.2	121.9	132.5	22.5	2.1	4.2	3.5	3.5	14.0	19.5

Source: MoALD, 2022.

Indigenous soil nutrient supply for N, P, K: A digital soil map developed by the Nepal Agricultural Research Council (NARC) in partnership with USAID's Feed the Future Nepal Seed and Fertilizer Project (NSAF) was used to extract levels of total nitrogen (N), available phosphorous (P_2O_5) and potassium (K_2O) supply of soils in each FtF district. These levels were then classified into very low, low, medium, high, or very high based on NARC's domain-specific fertilizer recommendations (NSSRC, 2023) (Table 2a). Fertilizer nutrient demands for N, P_2O_5, and K_2O were adjusted according to the specific soil nutrient levels in each district using multipliers based on NARC's agroecological zonation and calculations (NSSRC, 2023; NARC, 2024) (Table 2b). This approach tailored the soil fertility classification and nutrient demand to the local agroecological context of Tarai and Hill regions.

Adjustment for fertilizer nutrient demands: Specific multipliers were used to adjust fertilizer nutrient demands. The adjustment rules were based on soil nutrient supply status and the clay content of soil (Table 2b).

Table 2a: Soil native nutrient supply chart

Soil native nutrient supply categories	Terai			Mid-hills		
	N (%)	P2O5 (kg/ha)	K2O (kg/ha)	N (%)	P2O5 (kg/ha)	K2O (kg/ha)
Very low	<0.05	<10	<56	<0.03	<11.2	<55
Low	≥0.05 & <0.1	≥10 & <30	≥56 & <112	≥0.03 & <0.07	≥11.2 & <28.0	≥55 & <110
Medium	≥0.1 & <0.2	≥30 & <55	≥112 & <280	≥0.07 & <0.15	≥28.0 & <56.0	≥110 & <280
High	≥0.2 & <0.4	≥55 & <110	≥280 & <504	≥0.15 & <0.25	≥56.0 & <112.0	≥280 & <500
Very high	≥0.4	≥110	≥504	≥0.25	≥112	≥500

Source: NSSRC (2023).

Table 2b: Adjustment rules for fertilizer nutrient demand based on soil native nutrient supply.

Nutrient	Adjustment rule for nutrient supply categories					
	Very low	Low	Medium	High		Very high
				Clay ≤ 20%	Clay > 20%	
N	Multiply by	No	No	Multiply by	Multiply by	Multiply by
P_2O_5	Multiply by	No	No	Multiply by	Multiply by	Multiply by
K_2O	Multiply by	No	No	Multiply	Multiply by	Multiply by

Source: NSSRC (2023).

Nutrient use efficiency targets (N, P_2O_5, K_2O): Global average of nutrient use efficiency for the crops were estimated by following steps:

Step 1. Archival and processing of data: The fertilizer consumption data for different countries was accessed from the publicly available global FUBC dataset (Luderman et al., 2022) of the International Fertilizer Association (IFA). The top ten producing countries were chosen for rice (China, India, Bangladesh, Indonesia, Vietnam, Thailand, Philippines, Myanmar, Pakistan, Japan), wheat (Australia, Canada, China, France, Germany, India, Pakistan, Russia, Ukraine, and the USA), maize (USA, China, Brazil, India, Argentina, Mexico, Ukraine, Indonesia, South Africa, and Russia), potato (China, India, Russia, Ukraine, United States, Germany, Bangladesh, Poland, Netherlands, and France), and tomato (China, India, Turkey, United States, Egypt, Italy, Mexico, Brazil, Nigeria, and Spain).

In some cases where data were unavailable or appeared to be incorrect, they were excluded. This was the case for all nutrients for Ukraine and P_2O_5 and K_2O for Poland in potato; all nutrients in tomato for India, Turkey, Italy, Brazil, and Nigeria; K_2O for Pakistan and Japan in rice; K_2O for Pakistan in wheat; and K_2O for Argentina and Mexico in maize. Both cropped areas (ha), mainly derived from IFA estimates, while others were derived from FAO estimates, and total N, P_2O_5, and K_2O application (MT) were recorded for the latest reported year.

Step 2. Production and area harvested data: Data used to estimate nutrient efficiency targets for the specified crop countries described in Step 1 were recorded from FAO statistics(FAOSTAT, 2023).

Step 3: Calculate fertilizer used by the crop (MT/ha): Fertilizer used by the studied crop species was calculated by dividing the fertilizer consumption with the area under each crop, as reported in IFA (IFASTAT, 2024) or FAO (FAOSTAT, 2023).

Step 4. Compute crop yield (MT/ha): The average yields for crops were computed as the ratio of production and area harvested under the crop for the top ten rice/maize/wheat/potato/tomato producing countries.

Step 5. Estimate nutrient efficiencies: The partial factor productivity (PFP) of N, P_2O_5 and K_2O were computed as the ratio of crop yield (harvested produce) and fertilizer used by the crop, expressed as percentage (Equation 5):

$$\mathrm{PFP} = \frac{\text{kg harvested product ha}^{-1}}{\text{kg of nutrient applied}^{-1}} \tag{5}$$

PFP values derived from these calculations are shown in Table 3.

RESULTS AND FINDINGS

Cropped area and productivity status of FtF districts: Out of 20 selected western FtF districts, cropped areas under rice, wheat and potato were the largest in Kailali district (43%, 21% and 3% of total cropped land, respectively), while maize and tomato covers the maximum area under cultivation in Dang (20 percent and 0.6 percent of the cropped area, respectively) (Table 1). However, rice (56%), wheat (41%) and maize (49%) make up most of the total cropped areas in Kapilabastu, Rukum-West and Gulmi districts. Though they only make up a minor portion of the cultivated area, potato (3%) and tomato (1%) are primarily found in Rukum-East, and Rolpa districts, respectively (Figure 2).

Table 3: Average Partial Factor Productivity (PFP), standard deviation (SD) and 95 percent confidence interval lower limits (CI-LL) and upper limits (CI-UL) for N, P_2O_5 and K_2O in rice, wheat, maize, potato and tomato crops derived from data from the top ten producing countries.

Crop	Statistics	Yield (MT/ha)	PFP-N %	PFP- P_2O_5 %	PFP- K_2O %
Rice	Mean	4.9	51.5	133.3	211.4
	SD	1.4	28.9	58.1	134.8
	95 percent CI-LL	4.2	48.6	129.1	204.7
	95 percent CI-UL	5.5	54.5	137.5	218.2
Wheat	Mean	4.0	39.9	190.5	466.1
	SD	1.7	15.4	166.2	256.3
	95 percent CI-LL	3.3	37.8	183.8	457.3
	95 percent CI-UL	4.6	41.8	196.9	474.4
Maize	Mean	5.8[a]	58.5	183.6	268.8
	SD	2.3	29.1	106.8	149.0
	95 percent CI-LL	5.0	55.7	178.2	261.7
	95 percent CI-UL	6.6	61.3	189.0	275.8
Potato	Mean	26.8	244.3	373.1	321.3
	SD	14.4	85.5	176.6	174.6
	95 percent CI-LL	24.7	239.3	365.4	313.7
	95 percent CI-UL	28.8	249.4	380.8	329.0
Tomato	Mean	38.3[b]	178.3	315.0	386.0
	SD	14.7	45.8	38.2	160.8
	95 percent CI-LL	35.5	173.4	310.4	376.7
	95 percent CI-UL	41.1	183.3	319.5	395.3

Source: Authors' calculations ([a]Maize being predominantly rainfed, a 20% less yield was taken in fertilizer nutrient gap estimation; [b]30% less yield was taken, based on expert decision)

The average yields of rice, wheat, and maize in the selected districts are 3.1, 2.8, and 3.2 MT/ha, respectively (Table 1). Half of the districts produce 2-3 MT/ha of rice, eight districts yield 3-4 MT/ha, and two districts—Surkhet and Salyan—record over 4 MT/ha (4.2 and 4.1 MT/ha) (Figure 2). Most districts achieve wheat yields of 2-3 MT/ha, with three districts below 2 MT/ha and nine districts reaching 3-4 MT/ha; the highest wheat yield is in Kapilbastu at 3.7 MT/ha. Maize yields exceed 3 MT/ha in most districts, with only four districts producing close to 3 MT/ha. The highest maize yields are in Bardiya and Kanchanpur at 3.7 and 3.6 MT/ha, respectively. Potato yields range from 14 to 18 MT/ha, averaging 16.0 MT/ha, with Salyan reaching a maximum of 18.2 MT/ha (Figure 2). Tomato yields vary widely, from 9 to 24 MT/ha, with six districts near 20 MT/ha; the highest yield, 24.1 MT/ha, is in Palpa. In Nepal most of the OPV maize is grown in summer/rainy season under rainfed condition but hybrid maize is grown in winter season under irrigated condition. The hybrid seeds accounts 17% of total seeds used (Gairhe et al., 2021). Winter maize has high yield potential (> 6 MT/ha) than main season crop (2.0-2.5 MT/ha), however, raising a winter crop is a challenge due to lack of rainfall which is the major source of soil moisture for the resource poor farm families (Devkota et al., 2021). There is a large yield gap in maize for both mid hills and Terai of Nepal. While the experimental yield of OPV maize is 6.7 MT/ha and attainable yield is 5.7 MT/ha (Devkota et al., 2021), The national average of maize is 2.6 MT/ha (MoALD, 2018), resulting in a yield gap at 3.1 MT/ha. Similarly, the experimental yield of hybrid maize is 8.2 MT/ha and attainable yield is 7.3 MT/ha, so the actual yield gap is 4.7 MT/ha (Ghimire et al., 2016).

Fertilizer supply status of the 20 FtF districts: According to Fertilizer Distribution Management Directives of 2077 , the Agriculture Input Corporation Limited (AICL) and Salt Trading Corporation (STC) Limited have been designated for importing and selling subsidized chemical fertilizers in Nepal, with distribution shares of 70% and 30%, respectively (Vista et al., 2022). AICL and STC engage in the importation of fertilizers through international bidding processes, bringing them into the country via entry points such as Biratnagar, Bhairahawa and Birgunj. In exceptional and emergency circumstances, AICL procures chemical fertilizers through government-to-government agreements between Nepal and India, a process that typically spans over one and a half year. In the 20 western FtF districts selected for this study, the total sales of N, P_2O_5 and K_2O fertilizers are 16,136, 6,386, and 878 MT (Table 4), respectively, which aggregates to 29,645, 13,882 and 1,463 MT sale of urea, DAP and potash fertilizers.

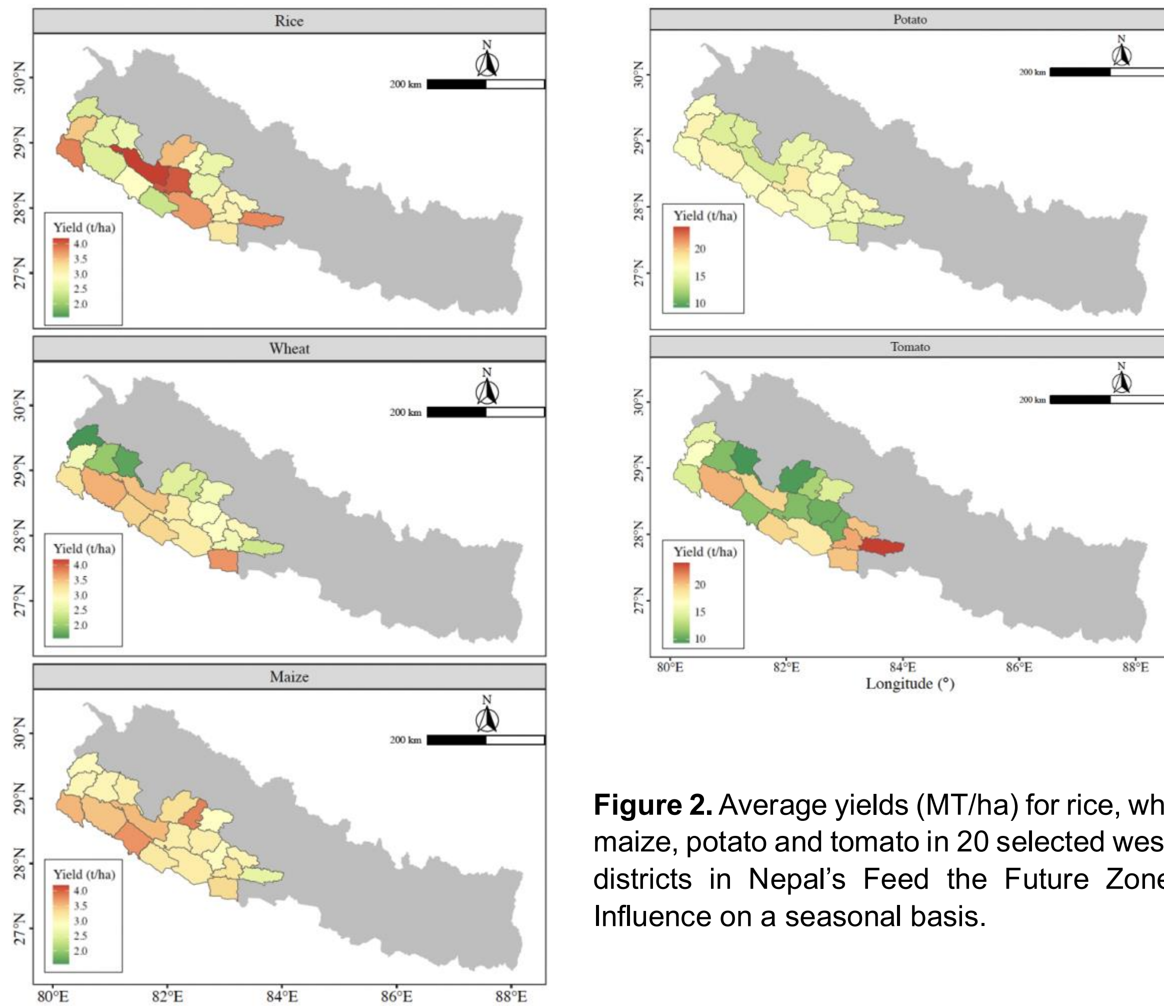

Figure 2. Average yields (MT/ha) for rice, wheat, maize, potato and tomato in 20 selected western districts in Nepal's Feed the Future Zone of Influence on a seasonal basis.

The highest N fertilizer sales were recorded in Kailali district (3,866 MT), followed by Kapilvastu (2,542 MT) and Dang (2,455 MT) (Figure 3; Table 4). Kailali also led in phosphatic and potassium fertilizer sales, with 1,319 MT of P_2O_5 and 308 MT of K_2O sold. Districts with minimal fertilizer sales included Baitadi (12 MT), Dadeldhura (20 MT), Doti (38 MT), Jajarkot (53 MT), Rukum East (55 MT), Rolpa (59 MT), and Achham (65 MT) with Rukum West reporting no sales. These districts similarly showed low sales of P_2O_5 and K_2O fertilizers. Kailali exhibited the highest fertilizer sales per unit area for all five crops combined at 46.2 kg/ha, followed by Dang (46.0 kg/ha), Kapilbastu (37.1 kg/ha), and Bardiya (34.2 kg/ha). Notably, eleven out of the 20 districts (55%) reported extremely low fertilizer sales per unit area, at less than 5 kg/ha.

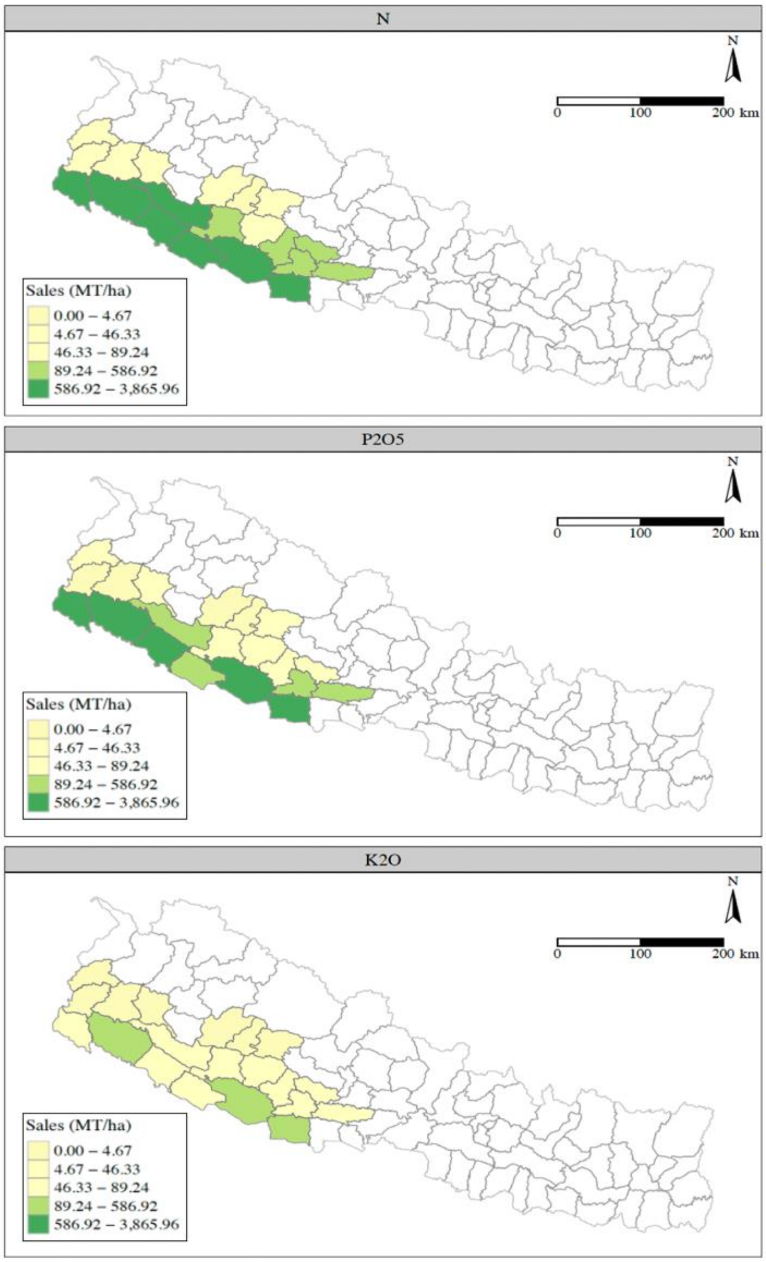

Figure 3. Sales of N (top), P_2O_5 (middle) and K_2O (bottom) fertilizers (in MT) in 20 selected western districts in Nepal's Feed the Future Zone of Influence seasonally.

Fertilizer demand and supply gaps in 20 FtF districts for major cereal and vegetables: The demand and supply (sales) of fertilizer exhibit imbalances. Data indicated that only 25-28%, 50-53%, and 10% of the required N, P_2O_5, and K_2O for the current yield of studied crops are available, resulting in deficits of 41,861 to 51,659 MT for N, 6,311 to 9,188 MT for P_2O_5, and 6,335 to 7,756 MT for K_2O when considering aggregate data for rice, wheat, maize, tomato, and potato. Considering current yield levels, Kailali district shows the highest demand for chemical N fertilizer at 7,137-7,197 MT, followed by Kapilabastu at 6,529-7,268 MT and Kanchanpur at 6,276-6,982 MT. Other FtF districts with substantial N fertilizer demand include Bardiya (5,259-5,834 MT), Dang (4,893-5,427 MT), and Banke (4,72-5,167 MT) (Figure 4; Table 4a). For P_2O_5, Kapilabastu has the highest demand at 2,192-2,333 MT, with Kanchanpur (2,063-2,196 MT), Kailali (1,651-1,743 MT), Bardiya (1,249-1,326 MT), Surkhet (675-716 MT), and Palpa (631-699 MT) following. Kapilabastu, Bardiya, Kailali and Banke show higher demands for K_2O at 1,299-1,377 MT, 1,086-1,149 MT, 980-1,036 MT, 905-954 MT, respectively. The lowest demand for N fertilizer is seen in Rukum East (918-997 MT), followed by Dadeldhura (1,023-1,129 MT), Jajarkot (1,199-1,320) and Rukum West (1184-1306 MT).

Table 4 District-wise sales (MT) of N, P_2O_5 and K_2O fertilizers seasonally.

District	Reported fertilizer sales (MT)		
	N	P_2O_5	K_2O
Achham	65	21	1
Arghakhanchi	150	91	8
Baitadi	12	7	1
Banke	1,719	575	52
Bardiya	2,020	752	76
Dadeldhura	20	3	4
Dang	2,455	926	111
Doti	38	4	1
Gulmi	96	75	10
Jajarkot	53	4	1
Kailali	3,866	1,319	308
Kanchanpur	1,459	854	86
Kapilabastu	2,542	957	94
Palpa	449	215	32
Pyuthan	155	86	16
Rolpa	59	63	5
Rukum east	55	12	4
Rukum west	0	0	0
Salyan	287	88	16
Surkhet	636	332	55
Total	**16,136**	**6,386**	**878**

Source: Authors' calculations, 2024 derived from national statistics.

Similarly, the lowest demand for P_2O_5 fertilizer was recorded in Rukum West (85-91 MT), Rukum West (194-98 MT) with these districts showing minimal nutrient input needs compared to others. K_2O demand was also notably low in Rukum East (68-71 MT), Jajarkot (72-76 MT), Rolpa (78-82 MT), and Baitadi (76-80 MT). To achieve target yields, the demand for fertilizers remains still higher. The required amounts range from 1,500 to 11,364 MT of N, 132 to 3,874 MT of P2O5, and 112 to 2,360 MT of K2O (Figure 5; Table 4b). Among the districts, Kapilabastu and Kanchanpur show the highest demands for all nutrients, while Rukum East, Rukum West, and Rolpa have the lowest fertilizer nutrient requirements.

Table 4a: Demand and deficit of N, P_2O_5 and K_2O fertilizers (MT) in 20 selected western f FtF districts with current crop yields.

District	Demand						Deficit					
	N		P2O5		K2O		N		P2O5		K2O	
	Low PFP	High PFP	Low PFP	High PFP	Low PFP	High PFP-	Low PFP-N	High PFP-N	Low PFP-P2O5	High PFP-P2O5	Low PFP-P2O5	High PFP-P2O5
Achham	1960	1767	422	397	264	250	-1895	-1702	-401	-376	-264	-249
Arghakhanchi	2038	1845	439	414	276	262	-1889	-1695	-349	-323	-268	-253
Baitadi	1707	1546	364	343	80	76	-1694	-1534	-356	-336	-79	-75
Banke	5167	4672	395	3270	573	543	-3448	-2953	179	171	-903	-853
Bardiya	5834	5259	1326	1249	804	760	-3814	-3239	-574	-497	-1072	-1010
Dadeldhura	1129	1023	308	291	188	178	-1109	-1003	-305	-287	-184	-175
Dang	5427	4893	457	431	811	657	-2972	-2438	469	495	-585	-546
Doti	1652	1496	360	340	219	207	-1613	-1457	-356	-336	-218	-207
Gulmi	2333	2113	183	172	326	309	-2237	-2017	-108	-98	-316	-299
Jajarkot	1320	1199	123	116	76	72	-1267	-1146	-118	-112	-75	-71
Kailali	7917	7137	1743	2345	1036	980	-4051	-3271	-424	-331	-728	-672
Kanchanpur	8727	6276	2196	2063	900	850	-5522	-4816	-1342	-1209	-686	-643
Kapilabastu	9086	6529	2333	2192	1377	779	-4727	-3987	-1375	-1235	-1283	-1205
Palpa	2064	1868	669	631	431	286	-1615	-1418	-454	-415	-399	-376
Pyuthan	1833	1662	141	133	246	233	-1678	-1507	-55	-47	-230	-218
Rolpa	1729	1570	131	124	82	78	-1670	-1511	-68	-60	-77	-73
Rukum east	997	918	98	94	71	68	-942	-864	-86	-81	-67	-64
Rukum west	1306	1184	91	85	150	143	-1306	-1184	-91	-85	-150	-143
Salyan	2955	2678	223	210	385	366	-2668	-2391	-135	-122	-370	-350
Surkhet	2614	2362	716	675	439	416	-1977	-1726	-384	-342	-384	-361
Total	67794	57996	15574	12717	8734	7512	-51659	-41861	-9188	-6331	-7856	-6635

Source: Authors' calculations, 2024.

Table 4b: Demand and deficit of N, P_2O_5 and K_2O fertilizers (MT) in 20 selected western FtF districts with achievable crop yields.

District	Demand						Deficit					
	N		P2O5		K2O		N		P2O5		K2O	
	Low PFP	High PFP	Low PFP	High PFP	Low PFP	High PFP	Low PFP-N	High PFP-N	Low PFP-P2O5	High PFP-P2O5	Low PFP-P2O5	High PFP-P2O5
Achham	4137	3726	882	829	539	510	-4072	-3661	-861	-808	-538	-509
Arghakhanchi	3171	2868	696	656	438	415	-3021	-2718	-606	-565	-430	-407
Baitadi	3613	3269	747	703	158	150	-3601	-3256	-739	-696	-156	-148
Banke	8760	7900	751	708	1777	1679	-7041	-6181	-176	-134	-1725	-1628
Bardiya	9684	8715	2343	2208	2068	1952	-7664	-6695	-1591	-1456	-1992	-1876
Dadeldhura	1755	1589	490	462	298	282	-1735	-1569	-486	-459	-294	-279
Dang	8155	7351	746	705	1073	1013	-5700	-4896	180	221	-962	-902
Doti	3368	3047	746	705	446	422	-3330	-3009	-742	-700	-445	-422
Gulmi	3685	3334	302	285	529	501	-3589	-3238	-228	-211	-519	-491
Jajarkot	2041	1854	194	183	118	112	-1988	-1802	-190	-179	-117	-111
Kailali	13815	12419	3293	3100	2015	1901	-9949	-8553	-1974	-1781	-1707	-1593
Kanchanpur	9887	8883	3208	3015	1147	1083	-8427	-7424	-2354	-2162	-1062	-997
Kapilabastu	11364	10194	3874	3642	2360	2223	-8823	-7652	-2917	-2685	-2267	-2130
Palpa	3495	3162	1124	1060	725	686	-3045	-2713	-909	-845	-693	-654
Pyuthan	2920	2647	238	225	410	389	-2765	-2492	-151	-138	-394	-373
Rolpa	2736	2483	241	229	136	129	-2677	-2424	-178	-165	-131	-124
Rukum east	1629	1500	163	156	117	112	-1575	-1445	-150	-143	-114	-108
Rukum west	1971	1786	140	132	220	209	-1971	-1786	-140	-132	-220	-209
Salyan	4136	3750	338	319	558	530	-3849	-3463	-249	-231	-543	-514
Surkhet	3457	3127	990	934	619	586	-2821	-2491	-657	-602	-564	-531
Total	98373	109091	34546	32551	13627	13165	-92955	-82238	-28160	-26166	-12750	-12287

Source: Authors' calculations, 2024.

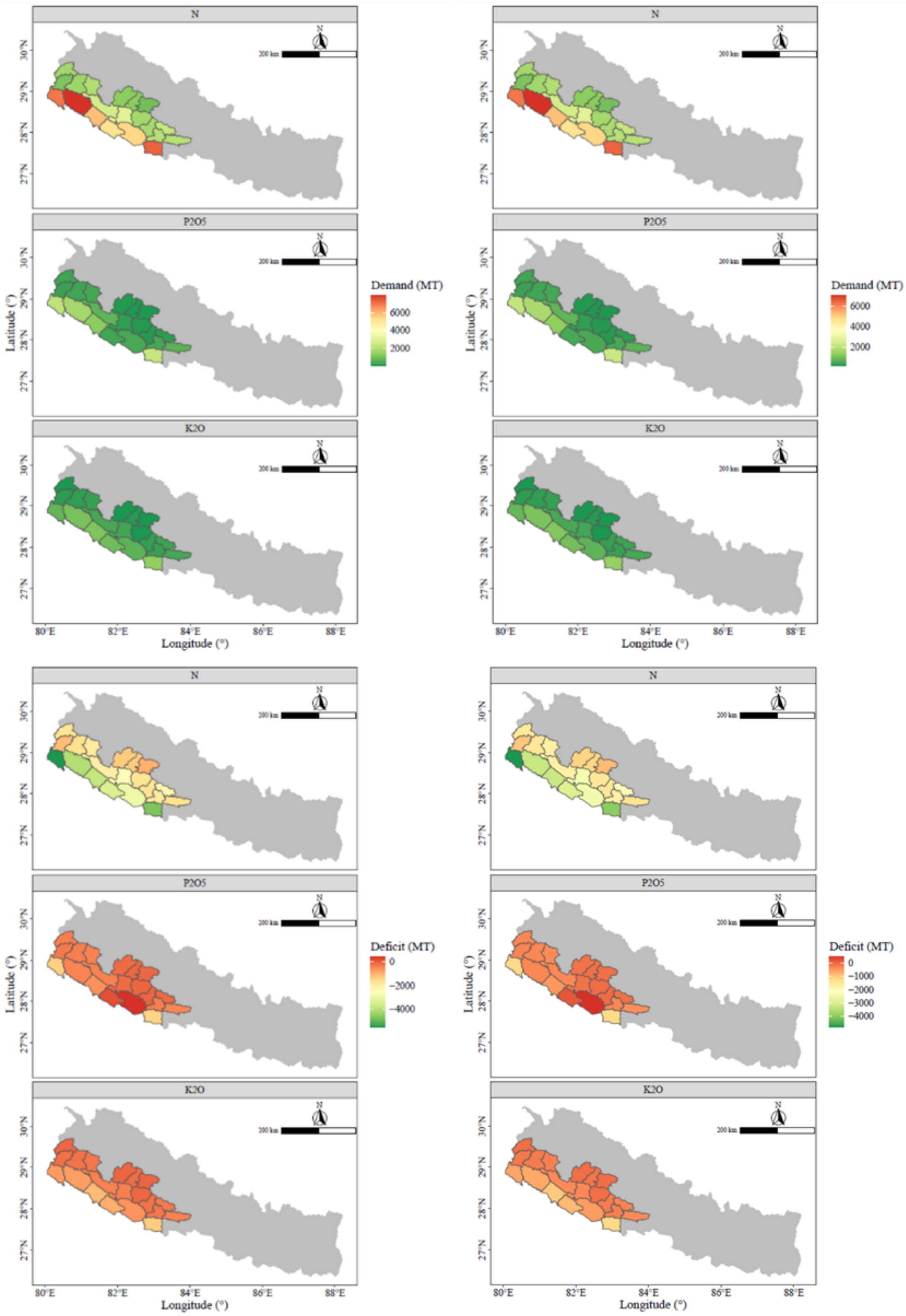

Figure 4 Demand (top) and Deficit (bottom) estimates for N, P_2O_5 and K_2O fertilizers (in MT) based on current yields and low (left panel) and high (right panel) partial factor productivity of nutrients in 20 selected western districts in Nepal's Feed the Future Zone of Influence.

Across most districts, nitrogen fertilizer demand is consistently 4-5 times higher than phosphorus and over five times higher than potassium, reflecting the intensive nitrogen needs for staple crops like rice, wheat, and maize. Notably, K_2O demand surpasses P_2O_5 demand in certain districts, including Banke, Dang, Gulmi, Pyuthan, Salyan, and Surkhet, indicating a distinct nutrient requirement likely influenced by the indigenous supply of nutrients from soils based on Digital Soil Map data, and differences in cropped area of the five species studied in this report. This discrepancy highlights the need for region-specific nutrient management strategies, tailored to local soil and crop nutrient demands, to optimize fertilizer use and improve crop yields across these districts.

The overall demands of N, P_2O_5 and K_2O fertilizers were estimated at 93,604-1,03,778 MT, 20,257-21,505 MT and 14,884-15,750 MT, respectively, considering achievable yield targets. This is six, three and seventeen times greater compared to the supply of N, P_2O_5 and K_2O fertilizers, respectively. When compared to achievable yield targets, districts with higher or lower fertilizer demand values showed similar trends; fertilizer demands with achievable yield targets were 1.5-2.0 times higher. Except for Dang, which has a surplus of P_2O_5 fertilizers for the current yield level, all FtF districts are experiencing a shortage of fertilizers. The gap between demand and supply varies greatly among districts, with deficits of 864 to 5,522 MT of N, 47 to 1,375 MT of P_2O_5, and 64 to 1,283 MT of K_2O with current yield (Table 4a); and 1,445 to 8.823 MT of N, 132 to 2,917 MT of P2O5, and 108 to 2,267 MT of K_2O (Table 4b). Considering current yield level, half of districts have a 1,000-2,000 MT N fertilizer shortage, whereas four to five districts have deficits of 2,000-3,000 MT and >3,000 MT, respectively (Figure 4). For achievable yields, however, at least four districts had a demand for N fertilizer of ~ 7000 MT, three districts have a demand of ~8000 MT, and eleven districts had a demand of <4000 MT (Figure 5). While Kailali, Kanchanpur and Bardiya are among the other districts most lacking in fertilizer nutrients availability, Kapilabastu is one of the most deficit districts in all three fertilizers.

Fertilizer has been in short supply in Nepal for decades (GoN, 2021; Gautam et al., 2022). Government imports meet only a quarter of the country's total demand, with the remainder acquired through informal channels, including cross-border smuggling from India (Krupnik et al., 2021). This study estimates that N-fertilizers constitute 75% of the overall (N+ P_2O_5 + K_2O) fertilizer demand. Six of the twenty Tarai districts (Bardiya, Banke, Dang, Kailali, Kapilabastu, and Kanchanpur) exhibit N demands that are 3-5 times higher and P_2O_5 and K_2O demands that are 3-9 times higher than those in the hilly districts examined. Consequently, these Tarai districts account for 48%, 66%, and 58% of the total N, P_2O_5, and K_2O shortfalls, respectively. The Tarai region, characterized by intensive crop production, experiences a greater fertilizer shortfall than hilly areas. Additionally, three Tarai districts have high demand for both P_2O_5 and K_2O, while Kailali and Kapilabastu exhibit high demand specifically for P_2O_5 and K_2O, respectively. These concentrated demands are likely due to extensive cultivation areas (e.g., Kailali, Kapilabastu, and Kanchanpur) and the production of oilseeds and pulses (e.g., Banke, Bardiya, Dang), which require these nutrients for optimal growth. Furthermore, the Tarai region has lower organic carbon levels compared to the hills and mountains; 56% of soil samples from the Tarai display low N, 30% medium, and only 14% high N levels (Vista et al., 2022). P and K contents are also low to medium in most Tarai soils, adding to the region's elevated fertilizer demand.

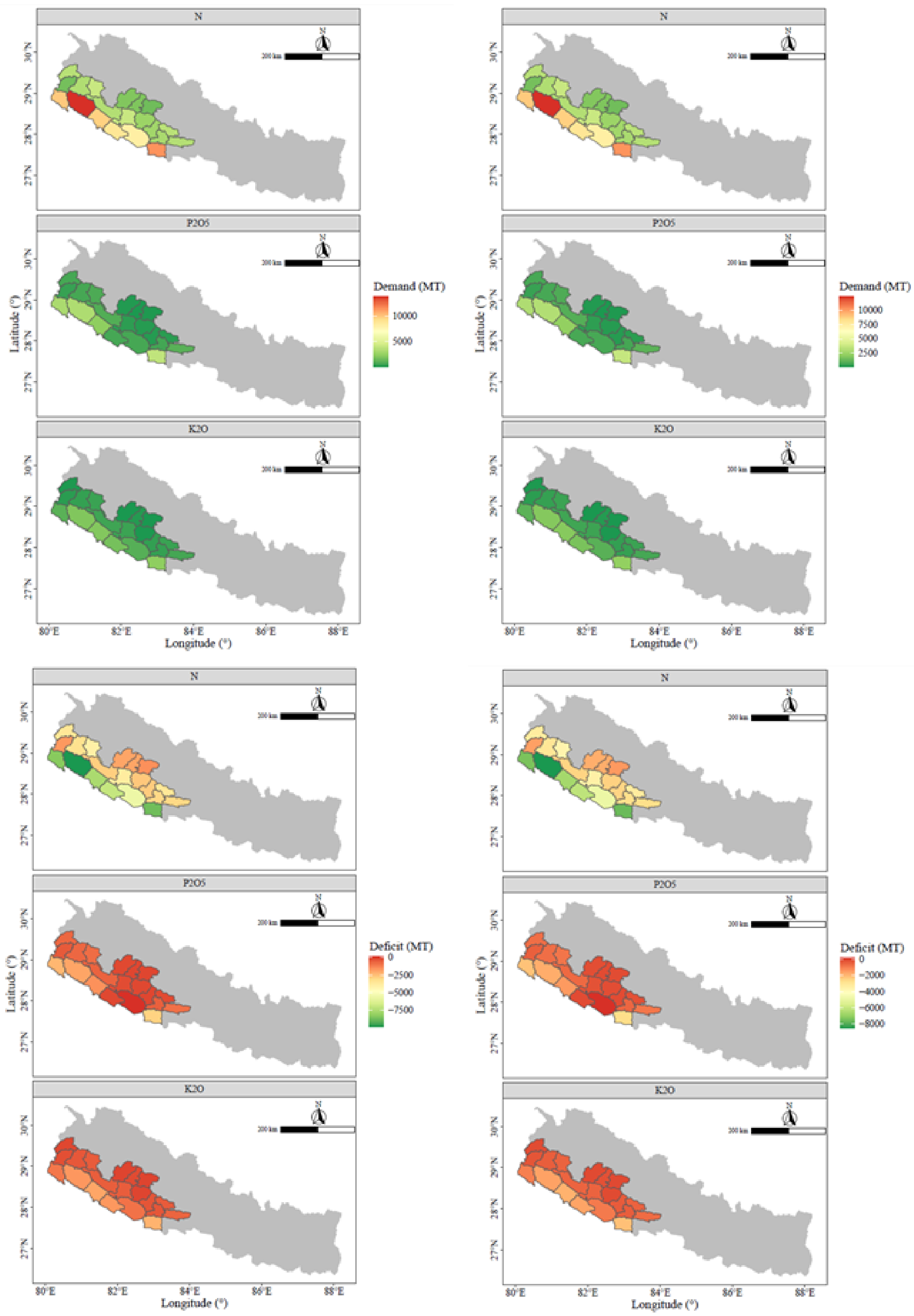

Figure 5 Demand (top) and Deficit (bottom) estimates for N, P_2O_5 and K_2O fertilizers (in MT) based on achievable yields and low (left panel) and high (right panel) partial factor productivity of nutrients in 20 selected western districts in Nepal's Feed the Future Zone of Influence.

Compounding these challenges, informal fertilizer imports further complicate the fertilizer landscape in Nepal. In 2020, a Finance Ministry study indicated that 72% of fertilizer imports were informal (Vista et al., 2022). Major border points for fertilizer trade in Nepal include Birgunj, Biratnagar, and Bhairahawa. Despite high demand, Kailali district shows a low fertilizer deficit, suggesting that informal channels via the Indian border may adequately supplement its fertilizer needs. Informally traded fertilizers comprise a significant portion of those used in Nepal. It is important to note that this study does not account for informal imports; therefore, gaps are based solely on government-reported fertilizer sales. Out of the 20 selected districts, six border India, and fertilizer deficits in these districts may fluctuate due to informal cross-border trade. Additionally, fertilizer supply is affected by the government's annual budget allocation, subsidy policies, and the timing of distribution.

Refining fertilizer distribution and import policies can address supply imbalances, particularly in high-demand districts where efficient logistics, storage, and timely delivery are essential. To ease financial pressure on smallholder farmers, targeted subsidies and credit facilities will ensure access to necessary fertilizers, even during shortages (Vanlauwe et al., 2010). Integrated Soil Fertility Management (ISFM), which combines compost, manure, and chemical fertilizers, partially meets nutrient needs while boosting soil health and resilience (Panta and Parajulee, 2021). Crop rotation and legume integration improve soil fertility by fixing atmospheric nitrogen (Ladha et al. 2022). These practices can help to maintain soil nutrient levels, support stable yields, and minimize additional fertilizer costs for farmers, and require increased emphasis in agricultural development programming and policies. Precision agriculture and Site-Specific Nutrient Management represent additional approaches for enhancing fertilizer efficiency (Baral et al., 2021; Dobermann et al., 2002). Crop rotation and cover cropping, especially with legumes, can enhance soil fertility naturally by fixing atmospheric nitrogen, reducing reliance on synthetic nitrogen fertilizers. Such methods can also help to reduce reliance on synthetic inputs, improve fertilizer recovery efficiency, and enhance soil structure and biodiversity, providing long-term benefits (Cassman et al., 2003; Scharfy et al., 2017; Al-Taey et al., 2018).

Study limitations: This study assessed the demand, supply, and gaps in chemical fertilizer availability across 20 selected western FtF districts in Nepal, focusing on five major crops—rice, maize, wheat, tomato, and potato—which are widely cultivated and consume most of the fertilizer supplied (MoALD, 2022). However, this focus may not fully represent total fertilizer demand across all crops grown in these districts throughout various seasons. The study also did not consider nutrient contributions from organic fertilizers, crop residue incorporation, or legume integration into cropping systems, factors essential for a complete understanding of nutrient needs. Reliable measurements of PFP for rice, wheat, maize, tomato, and potato are scarce in Western Nepal and South Asia, particularly for non-nitrogenous fertilizers. Consequently, PFP data were derived from national-level crop yields and fertilizer use in the top 10 producing and fertilizer-consuming countries for these crop species, which differ climatically from Nepal and may introduce some error in the dataset and methods applied in this study. However, based on this study and the data gaps encountered, further research is needed to obtain accurate PFP estimates for these key crops in western Nepal. These findings therefore offer a preliminary assessment of chemical fertilizer demand for major crops, intended to guide policymakers on the supply and distribution of subsidized fertilizers. Similarly, this study focused primarily on macronutrients, while balanced use of micronutrients is also a challenge in South Asia and Nepal (Kishore et al. 2021). Future efforts to unpack these challenges should therefore also consider the role of micronutrients, with refinement in Nepal's Digital Soil Map needed to address these issues.

Future studies should adopt a holistic approach by including a broader range of crops and integrating multiple nutrient sources, such as organic inputs and crop rotation practices. Research should also examine the impact of different varieties and irrigation strategies on fertilizer demand. These comprehensive analyses will improve understanding of nutrient requirements in Nepalese agriculture, ultimately supporting more effective policy formulation and implementing more sustainable agricultural practices.

SUMMARY AND RECOMMENDATIONS

This report addresses critical fertilizer use challenges in Nepal's agricultural sector, emphasizing the low application rate of synthetic fertilizers for rice, wheat, maize, tomato, and potato relative to neighboring countries, alongside existing supply and demand gaps. Despite recent increases in fertilizer use, productivity for staple crops like rice remains insufficient to support Nepal's growing population, raising concerns over food security and economic stability. Low fertilizer application stems from multiple factors, including market inefficiencies, inadequate distribution networks, and limited farmers' knowledge of nutrient management practices. Current subsidy programs and distribution efforts do not meet demand consistently or effectively, resulting in shortages and low fertilizer recovery efficiency. While informal fertilizer imports from India offer some relief, they remain inconsistent, unregulated, and unreliable in their current form.

To address these challenges, this study employed a data-driven approach to estimate fertilizer demand across 20 western FtF districts, focusing on nutrient needs for five staple crops: rice, maize, wheat, potato, and tomato. Findings, which include assessments of indigenous soil nutrient capacity—a novel feature compared to conventional fertilizer assessment methods—reveal considerable deficits in N, P_2O_5, and K_2O fertilizers, especially in high-demand regions like the Terai, where intensive farming heightens nutrient requirements. Variability in soil nutrient availability and production needs across regions highlights the importance of precise, region- and crop-specific fertilizer demand forecasting. Addressing these challenges will require a coordinated approach to strengthen supply chains, enhance data-driven demand forecasting, and support farmers in adopting improved management practices through partnerships spanning the public and private sectors. Key recommendations include advancing data use in supply forecasting, optimizing fertilizer distribution logistics, enhancing soil fertility management practices, and refining policies to support integrated nutrient management strategies that will build resilience in Nepal's agricultural system. These are summarized below.

Scientifically rigorous, data-driven methods to overcome nutrient deficits: Developing a scientific demand forecasting system is central to addressing Nepal's fertilizer deficit. Fragmented data collection limited robust data (particularly influencing the robustness of PFP estimates), and inadequate coordination between researchers and policymakers hinders accurate forecasting, contributing to shortages and inefficient resource use. A collaborative data-sharing network among key agencies such as NARC, CGIAR Centers, the donor community, and local agricultural offices would enable data consolidation, supporting an effective forecasting system. Systematic data collection at the municipal level and refined tracking of farmers' fertilizer application rates could improve demand-supply forecasting and alignment. Enhanced support for NARC's collaboration with CGIAR Centers and the FAO, for example – which have long-term in country presence and demonstrated ability to provide strong technical and scientific assistance lacking in other development agencies – could offer foundational support in data infrastructure, technical expertise, and resource mobilization, facilitating phased development of a responsive and accurate forecasting system.

Improve Nepal's fertilizer supply chain: Weak infrastructure and inconsistent import policies contribute to frequent delays, limiting fertilizer availability during critical growth stages. Streamlining customs processes, reducing bureaucratic hurdles, and optimizing logistics through improved storage and coordinated transportation could help ensure that fertilizers reach high-demand areas more efficiently. Although the current system relies heavily on farmer cooperatives, the private sector may offer additional benefits that merit exploration.

Leverage the private sector: Expanding private sector involvement in fertilizer distribution could help meet demand but require careful regulation to prevent monopolistic practices that might inflate prices. Simplified regulations for private sector entry, paired with price controls, would help secure smallholder access to essential nutrients. Establishing corporate social responsibility guidelines could further support marginalized farmers' access to affordable fertilizers in areas the private sector might otherwise deprioritize. Incentives for private distributors to enter underserved regions, along with government oversight, would ensure fair competition and affordability. This balanced approach would encourage private investment while safeguarding smallholder accessibility.

Create an enabling environment for Integrated Soil Fertility Management: ISFM offers a promising approach to reduce reliance on synthetic fertilizers while gradually improving soil health. Integrating ISFM into agricultural extension services through targeted outreach could increase farmer interest by demonstrating the benefits of combining organic and inorganic fertilizers. Support mechanisms, such as subsidies for organic fertilizer inputs and composting tools, would further encourage adoption. High-demand areas could serve as pilot sites to evaluate ISFM's benefits under local conditions, potentially generating broader support. Beyond ISFM, crop rotation and legume integration are essential for maintaining soil quality and reducing nitrogen fertilizer needs. However, effective implementation remains challenging for many farmers. Nepal's Agricultural Knowledge Centers could collaborate with agro-vets and farmers to enhance awareness of crop rotation schedules that incorporate nutrient-fixing legumes. Small grants to agro-vets for building markets for inoculants in high-rotation potential areas could incentivize legume-inclusive cycles and provide a foundation for experimentation.

Invest in regularly improving Nepal's Digital Soil Map: Regular updates to refine Nepal's high-resolution Digital Soil Map are vital for data-driven fertilizer application, crop planning, and nutrient management. Upgrading the map's resolution and expanding data points across regions would increase accuracy and relevance, enabling region-specific soil recommendations. Expanded soil sampling and standardized data practices are essential for improving NARC's data reliability. Establishing a digital repository and raising awareness among private sector actors would help expand the map's utility. A digital platform accessible to agro-vets and farmers could translate soil data into actionable recommendations, providing crop-specific nutrient guidance to support decision-making at district, municipal, and farm levels.

Prioritize research and market alignment to support micronutrient use: Although insufficiently prioritized by the donor community, research on micronutrient needs remains critical to supporting balanced fertilizer application. Integrating micronutrient assessments and improvements in Digital Soil Map resolution and data supply into existing soil management programs will build a knowledge base reflecting Nepal's soil diversity and the need for refined demand-supply gap assessments. Collaboration with research organizations would facilitate studies on region- and crop-specific micronutrient needs, enabling policymakers to develop comprehensive, tailored recommendations. Improving data collection and research capacity is essential for effective policy alignment. Establishing a national digital database with support from international research organizations to centralize soil health, crop yield, and fertilizer demand data would improve evidence-based policy and resource allocation. Training district-level data collection teams will enhance data quality and consistency, supporting policies responsive to local realities.

Take action to limit market distortion through informal trade: Monitoring and regulating informal fertilizer imports from India is critical to ensuring quality and supply stability. Much of the cross-border trade in fertilizers is informal. Increased monitoring at border points could reduce reliance on unregulated imports that distort markets. Providing economic incentives for registered suppliers would encourage a shift from informal to formal channels, ensuring fertilizer quality and regulatory compliance.

Nepal's challenges in fertilizer access, nutrient management, and data gaps present significant barriers to food security and agricultural sustainability. The recommendations outlined here aim to address these issues with practical, collaborative, and scalable solutions aligned closely with USAID's FtF priorities. Improving data collection, enabling targeted fertilizer supply, and fostering partnerships to secure technical and financial resources—particularly from the private sector—will be essential for building resilience in Nepal's agricultural system. Prioritizing a refined Digital Soil Map, alongside methodological improvements in fertilizer supply-demand assessment and data-driven supply distribution, is necessary to establish a robust foundation for sustained productivity gains and effective nutrient management in Nepal's agricultural landscape.

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