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NUTRIENT RATIONALIZATION IN NIGERIAN COMPOUND FERTILIZERS (NPK) WITH SPECIAL FOCUS ON PHOSPHORUS AND POTASSIUM UTILIZATION

NUTRIENT RATIONALIZATION IN NIGERIAN COMPOUND FERTILIZERS (NPK) WITH SPECIAL FOCUS ON PHOSPHORUS AND POTASSIUM UTILIZATION

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TABLE OF CONTENTS

Acknowledgments *iv*

Acronyms and Abbreviations *v*

Executive Summary *vi*

I. Introduction **8**

II. USAID MARKETS' Intervention and Support to Fertilizer Research and Recommendations **8**
- A. The MARKETS' Project 8
- B. MARKETS' Support to Farmers and Support to Fertilizer Research and Recommendations 9

III. Problems With "Blanket" or "Generic" NPK Recommendations **9**

IV. General Scope of Work **11**

V. Specific Scope of Work: Define Nutrient Requirements for Project Area Interventions as Represented by MARKETS' Sorghum and Cowpea "Logistical Fixes" **11**

VI. MARKETS' Sorghum Locations and Recommendations **12**
- A. Sorghum Locations and Nutrient Status 12
- B. Federal Fertilizer Department Recommendation 14
- C. Examples of Soil Variation Based on Soil Maps of Kaduna 14
- D. Current Recommendation in All States 16
- E. Three Recommendations Suitable for MARKETS' Field Demonstrations 19
- F. Two Recommendations Suitable for MARKETS' Field Demonstrations 19
- G. Summary of Issues Connected to K Availability and High Analysis Fertilizers 19

VII. MARKETS' Cowpea Locations and Recommendations **21**
- A. Federal Fertilizer Department Recommendation 21
- B. Agro-ecologies Recommendations 21
- C. Recommendations as per MARKETS' Cowpea Logistical Fix 22

VIII. General Recommendations for Test Crops 23

A. Essentiality of Nutrients in the Recommendations 23
B. The Test Crops 23
C. Summary 25

IX. MARKETS' Soil Fertility Assessment Resources 26
A. FAO Fertility Map: Its Strengths and Limitations 26
B. MARKETS' Soil Testing Capability: 200 Mobile LaMotte Field Soil Test 26

X. Conclusion 30
A. General Comments 30
B. History and Observations on the FAO Map and Macro-Nutrient Overloading 30
C. The Soil and Its Knowledge 32
D. Alternatives to Conventional Laboratory Testing 33
E. Actions Needed Now by Stakeholders 34

XI. Summary 38

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ACRONYMS AND ABBREVIATIONS

ADP	Agricultural Development Project
AFS	African Fertilizer Summit
AIDA	Agri Input Dealers Association
APMEU	Agricultural Projects Monitoring and Evaluation Unit
CAN	Calcium Ammonium Nitrate
CEC	Cation Exchange Capacity
DAP	Di-Ammonium Phosphate
FAO	Food and Agricultural Organization
FACU	Federal Agricultural Coordinating Unit
FAI	Fertilizer Association of India
FCT	Federal Capital Territory
IAR	Institute of Agricultural Research
IBRD	International Bank for Reconstruction and Development
IITA	International Institute of Tropical Agriculture
IFDC	An International Center for Soil Fertility and Agricultural Development
KCl	Potassium Chloride
MARKETS	Maximizing Agricultural Revenue and Key Enterprises in Targeted Sites
MOP	Muriate of Potash or KCL
NAFCON	National Fertilizer Company of Nigeria
NCRI	National Cereals Research Institute
NNSTC	Nigerian National Soil Testing Campaign (proposed)
NSPFS	National Special Program on Food Security
SSP	Single Super Phosphate
USAID	United States for Agency for International Development
UNN	University of Nigeria, Nsuka

EXECUTIVE SUMMARY

1. Using the soil fertility map completed by FAO in 2005, MARKETS contracted with a well-known expert to assess the likely P and K nutrient requirements for targeted locations and crops where MARKETS has focused its support to crop alliances for sorghum and cowpea.

2. The three macro-nutrients N, P, and K, were targeted to determine what total nutrient ratios should be based on FAO soil parameters (topsoil and subsoil) in the states where MARKETS has production support activities. These parameters were compared with general practices and official recommendations for fertilizer applications.

3. The results were surprising, in that soil parameters given by the FAO map indicated radically different total nutrient ratios than those used historically by farmers, and officially recommended. The implication is that in several major production regions there has been overdosing of both P and K nutrients resulting in waste to the economy and excessive production costs to the farmers.

4. To illustrate, a simple calculation based on conservative estimates of waste indicates that Kano and Kaduna lost about US$ 1.5 million in 2005 alone due to overdosing nutrients. This is based on estimates of fertilizer receipts to these states in 2005 and using 2006 prices of landed fertilizer product and projected transport costs. It does not include marketing and production costs. Projected to the entire Federation and over 25 years, the probable economic loss to the country has been significant.

The Savings that Keep on Saving

At the national level, the greatest 'fertilizer-soil' subsidy that a farmer needs is to identify the capability and suitability of his soil. This should be given at token to the farmers as knowledge to help them reduce costs by purchasing appropriate fertilizers and teach them the importance of soil testing. By reducing farmers' cost, their incomes improve.

5. The FAO soil map reveals that this overloading of P and to a lesser extent K depends on the soil, crops, and the regions. It should be noted that while new blends such as 25:10:10, 20:10:10, and 27:13:13 are available, these are not addressing the critical issue of soil fertility. Using existing ratios such as a 2:1:1 for sorghum virtually precludes the use of urea as a top dressing, with actual practice moving to a one-time application at seeding. The N dose is too high for a one-time initial application, and top dressing of N is required later in the cropping season. This is a problem of not using high nutrient

analysis fertilizers such as urea, Di-Ammonium Phosphate (DAP), and MOP. These fertilizer types were a key factor in making the “Green Revolution” in Asia.

6. Overdosing likely has produced negative impacts on both agricultural production and soil status at the locations analyzed and in early analysis is also affecting farm productivity in other regions of Nigeria. Inappropriate fertilizer can cause soil chemical degradation, imbalances, and particularly, soil mining. Focus must be made on N and K sourcing and amounts of application to use the P reserve efficiently without mining P and associated micronutrients.

7. The discovery of the need for updated and improved fertilizer recommendations in the areas covered by this study has created an additional need to address major policy issues, which are highlighted in the conclusion.

8. Based on the findings from this report, a comprehensive approach on a national level to determine the real fertilizer needs of Nigerian soil is warranted. This approach should consider the types of fertilizers currently being used compared to fertilizer types needed, and where and in what quantity they are needed.

9. Finally, the report recommends actions that can be taken by stakeholders to rectify major imbalances in nutrient application and soil use from the farm level to national policy.

I. INTRODUCTION

Recommendations for fertilizer applications for the three macro-nutrients N, P, and K (NPK) in Nigeria have remained “generic” over the years. Although this practice has been condemned and discredited as inadequate, efforts to change it have not been successful.

There are at least four reasons for this: 1) inadequate funds for research, 2) lack of systematic soil testing and subsequent NPK recommendations, 3) failure of agricultural development projects (ADPs) and suppliers to approach the problem of local soil fertility needs, and 4) inadequate funds for agri-input dealer and farmer training on best practices of agri-input use.

The strenuous efforts of researchers over many years to produce fertility maps were bolstered in 2005 by the development of the Food and Agriculture Organization’s (FAO) national soil fertility map for Nigeria. Despite this progress, Nigeria remains in urgent need of a national nutrient strategy to: 1) secure for farmers’ appropriate nutrient-balanced fertilizer that can be applied to specific soils and crops, and 2) that addresses national soil fertility concerns such as nutrient mining.

II. USAID MARKETS’ INTERVENTION AND SUPPORT TO FERTILIZER RESEARCH AND RECOMMENDATIONS

A. The MARKETS Project

USAID/Nigeria is implementing the five-year Maximizing Agricultural Revenue and Key Enterprises in Targeted Sites (MARKETS) activity. MARKETS focuses on expanding economic opportunities in the agricultural sector by increasing agricultural productivity, enhancing value-added processing, and increasing commercialization through private-sector led and market-driven growth and development. MARKETS works along the commodity development chain from primary producer to processor to end-users with the aim of reaching significant numbers of agricultural households and rural enterprises. The activity aims to transform Nigerian agriculture in selected areas from low-input/low-output, subsistence farming to commercially competitive agriculture. It hopes to identify and address priority food and cash crop/non-crop systems where productivity gains will lead to: 1) significant impacts on the economy, and 2) improvements in household livelihoods of those involved in the agriculture sector. In addition, the project’s activities will support off-farm agricultural enterprises that will enhance the transformation process and generate employment.

B. MARKETS' Support to Farmers and Support to Fertilizer Research and Recommendations

To ensure that processors and their consumers have the right type and quality of commodity, MARKETS works with fertilizer suppliers and farmers.

To facilitate farmers' success, MARKETS supports determining appropriate technology, in this case the right application of inorganic nutrients. Additionally, a MARKETS' objective is to make Nigerian farmers more competitive by cutting costs through applying inputs (technology) in an economical manner and one friendly to the environment. Certain agricultural practices, though thought to be beneficial, induce negative results both for farmers' income and for soil. In this context, MARKETS seeks to determine appropriate nutrient balances with regard to the farmers it assists directly. In so doing, it also raises issues about appropriate nutrient use in the production practices of millions of Nigerian farmers.

III. PROBLEMS WITH "BLANKET" OR "GENERIC" NPK RECOMMENDATIONS

The well-known condemnation of blanket NPK recommendations has its scientific bases in the following facts:

1. *Nigerian soils are inherently micro-variable within short distances*. The spatial variability lends itself to geological formation of the soil that ranges from rocks of the basement complex, to very old rock formations to the northern fringe, recent alluvium, old alluvium, Aeolian sands, Kerri Kerri formation, i.e., Lancastrian and lagonal sediments, mangrove swamps, and coastal plain sands. These different formations impose their mineralogical impacts on the particles that form the soil in different locations. This is complicated by geographical location, climatic factors, vegetation, and land use. The implication is that the native soil fertility is not uniform; therefore, any amendment of such soil with exogenous material like fertilizer must be applied with caution after appropriate soil testing and precise calculation for nutrient balancing. Therefore, there is no scientific basis for extrapolative application of fertilizer, except if the soil grouping is found to be the same across the same region. If the soil does not have the essential nutrient in its mineralogy, there is a need to find a sustainable way of adding and conserving the nutrient and making it available to the crop when needed.

2. *Farm activities add crop residue to the soil.* Peasant farmers maintain their production and still feed 75 percent of the population with little or no fertilizer application. It is also estimated that 45 percent of nitrogen used in the universe comes from biological nitrogen fixation. This is also unaccounted for. The amount of natural nutrient recycling occurring in the agricultural field suggests a way to replenish our fragile soils. These generally nutrient-deficient soils are the major medium of crop production and the capital budget on which our food security is anchored.

3. *Nigerian environmental forces, particularly climatic factors, negatively affect the soil and production processes*. Therefore, soil management or, more holistically, cultural practices, become the solution to sustainable crop production and the key to food security.

4. *Inappropriate fertilizer materials, single or compound, cause chemical degradation, imbalances, and particularly, soil mining*. An example is application of compound fertilizer NPK 15-15-15 with a ratio of 1-1-1, which is discordant with the ratio of need of plants and existing ratio of these component elements in the soil. The proportionate need of NPK is N>P>K. The implication is that more K than is needed is always added to the soil, resulting in overloading. A statutory crop culture is a colossal waste of scarce financial and economic resources. Further, overloading the soil causes imbalance and low crop yield, low crop quality, and nutrient mining. Nutrient mining is the loss of valuable and irreplaceable natural resources and national capital. To sustain yield at the individual farm level, the peculiarity of each site, soil origin, climate, vegetation, cropping history and particularly soil chemical make up must be considered. Two main challenges have emerged for farmers and stakeholders:

    - Determining soil needs to meet the crop needs that grow on it. This is necessary for the crop to express its maximum genetic potential in an enabling soil environment for optimum yield.

    - Using available fertilizer materials to blend different grades appropriate for different crops in different ecologies based on the soil fertility map of Nigeria developed for phosphorus, potassium, and other nutrients by the FAO.

IV. GENERAL SCOPE OF WORK

To begin determining appropriate nutrient combinations for its targeted commodities and production sites, MARKETS based this study on the following general scope of work:

“Determine an appropriate mix of NPKs for selected areas and crops taking into account the FAO 2005 nutrient maps.” (Phosphorus and potassium fertility classes top 0-15cm and subsoil 15-30cm showing fertility in c.mol./kg and subsequently validated by MARKETS’ in-house soil testing results.)

V. SPECIFIC SCOPE OF WORK: DEFINE NUTRIENT REQUIREMENTS FOR PROJECT AREA INTERVENTIONS AS REPRESENTED BY MARKETS’ SORGHUM AND COWPEA “LOGISTICAL FIXES”

The project obtained the FAO fertility map for K and all nutrients and studied the classification for the states where MARKETS’-mandated crops will be grown. The crops are sorghum, cowpea, and rice primarily in northern Nigeria. MARKETS’ interventions are defined by crop and location through the fertilizer “logistical fixes” (expected fertilizer delivery and application areas where crop out-growers are to produce) for sorghum and cowpea. These logistical fixes are the stated requirements of MARKETS’ regional production coordinators (RPC) who determine sites both for demonstrations and intensive production. This report focuses on applying this new approach to rationalizing nutrients to these locations.

Recommendations will be made based on crop and locations identified in the fertilizer logistical fixes.

VI. MARKETS' SORGHUM LOCATIONS AND RECOMMENDATIONS

			Fertilizer Quantity By Types (Bags)			
States	**Location***	**Ha**	**27:13:13**	**15:15:15**	**20:10:10**	**18:46:00**
Kaduna	Yakasuwa	300	1200			
	Gure	100	400			
	Kad Environ	800	3200			
	Kachis Rail	100	400			
	Saminaka	n/a		1200		500
	Kanfanchan	n/a		500	500	
Kano	Rogo	100	400			
	T/Wada	100	400			
	Kura	100	400			
Katsina	Yankara	200	800			
	Subuwa & Kayara	100	400			
	Malumfeshi	100	400			
Bauchi	Dogwu	n/a	700	550		
	Bauchi	n/a	700	550		
	Langtan	n/a	1000	550		
	Shendam	n/a	1000	550		
G.TOTAL		2000	11400	3700	500	500
# of Trailers (30 Te Cap)			13	19	6.2	11
Total # of Trailers Required	*Approximately 41*					

** Locations based on MARKETS' logistical fertilizer fix for the sorghum alliance*

A. Sorghum Locations and Nutrient Status

A1. Kaduna — Potassium K

The two calibration levels are:

i. Topsoil (0-15cm)
ii. Subsoil (15-43cm)

Nutrient situations noticed:

i. Northeast part above one-quarter of the state tests **low** (0.21-0.3) c mol//kg

ii. Northwest, central southwest and eastern parts test **moderate** (0.3-0.6) c mol/kg

iii. Northeast part, southeast three-quarters test **moderate** (0.31-0.6) c mol/K
Northeast central, southwest test **low** (0.21-0.3) c mol/kg and pockets of very low in extreme west (0-0.2) c mol/kg

Comment: The topsoil **(intensity factor**) or active level of nutrient may be **adequate** at the same time that the (**capacity factor)** K reserve may be **low.** Kaduna state is a case study of contrasting scenarios. Management of K to sustain continuous cropping is critical in these soils.

A2. Questions and Issues

The following questions and issues need to be addressed:

- What is the K status of the geological formation?

- N and K factors that range from: N – very low, to low K – low to moderate and low K reserve need to be managed.

This is complicated by the fact that P is adequate: > 20mg/kg

A sustainable fertilizer formulation will now focus on nutrient balance to avoid oversupply of P, which is adequate. Focus must be on N and K sources that will utilize efficiently the P reserve for high yield and fertility maintenance without mining the P and associated micronutrients. If copious P is added, there is tendency to create a P-Zn antagonism and tie up micronutrients.

Based on the above scenario, NPK 15-15-15 is statutorily ruled. The problem with this ratio is seen in the following deficiency/status:

N>K and no P problem

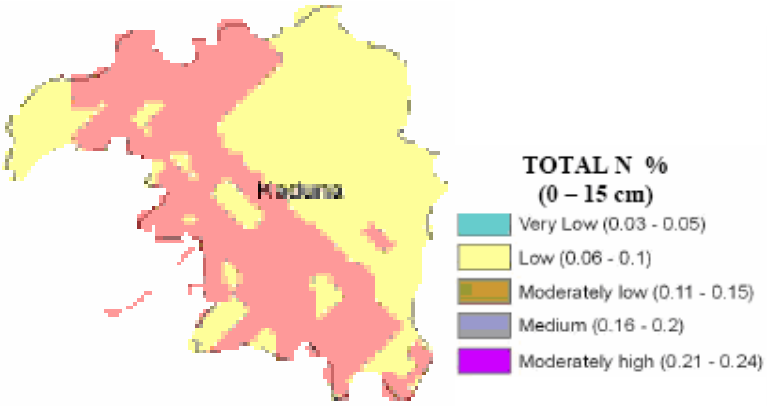
P- Starter dose can be administered since the efficiency of applied nutrient is greater than native source. Suggested fertilizers will be urea and potassium chloride (KCl). Based on this, the recommendations from a reputable government organization are provided below for comparison purposes only.

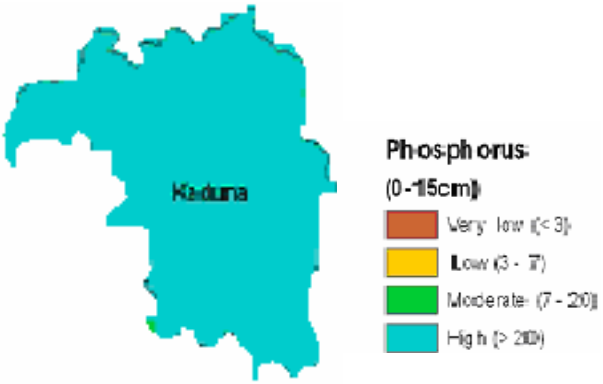
B. Federal Fertilizer Department Recommendation (Ministry of Agriculture)

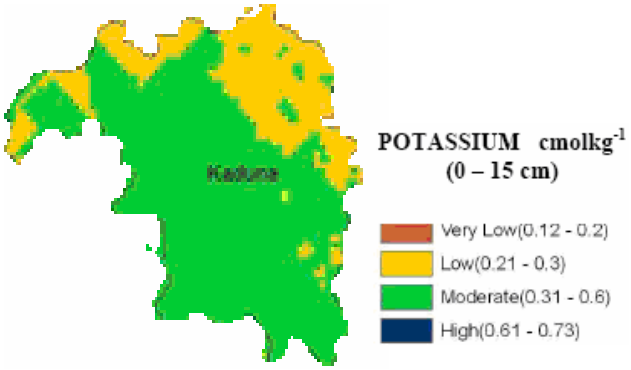
Nutrient	Fertility	Class	Nutrient Rates
N	Low	64	Urea (142 kg, 3 bags) CAN (246 kg, 5 bags) 20-10-10 (320 kg, 6.25 bags)
	Medium	32	Urea (71 kg, 1.5 bags) CAN (123 kg, 2.5 bags) 20-10-10 (160 kg, 3.25 bags)
	High	16	Urea (35 kg, .75 bags,) CAN (61kg, 1.25 bags) 20-10-10 (180 kg, 1.75 bags)
P	Low	32	SSP (178 kg, 4 bags) TSP (71 kg, 1.5 bags)
	Medium	16	SSP (89 kg, 2 bags) TSP (36 kg, 1 bag)
	High	Nil	Nil
K	Low	30	MOP (52 kg, 1 bag)
	Medium	15	MOP (25 kg, 1.2 bags)
	High	Nil	Nil

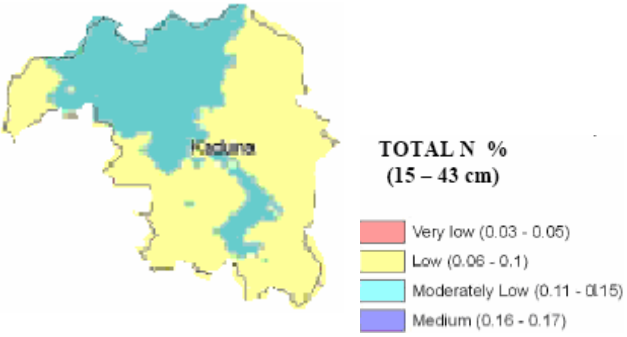
C. Examples of Soil Variation Based on Soil Maps of Kaduna

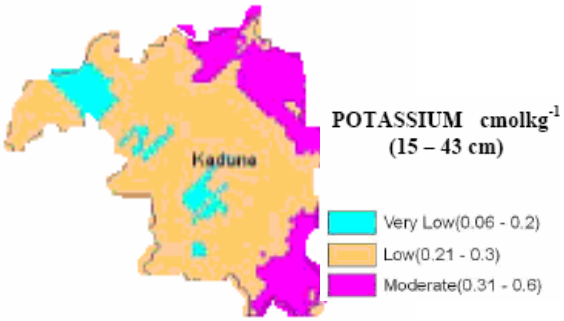
The first six maps of Kaduna below show the variation in macro-nutrients across states and demonstrate the inappropriateness of “blanket” recommendations for states. The next two maps of organic matter and pH demonstrate the need for different management according to these critical soil factors. The final agro-ecological map illustrates the complexity of the entire agricultural and environmental system.



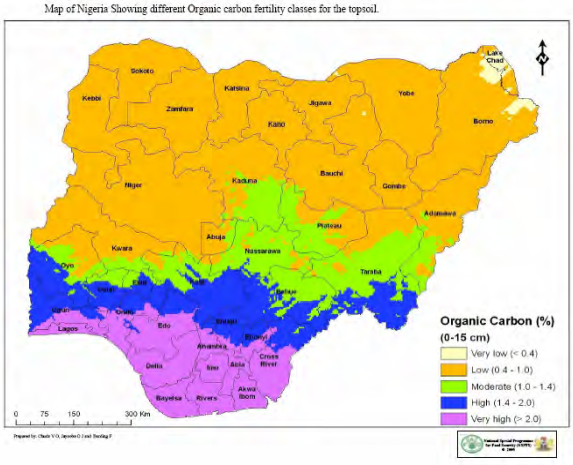




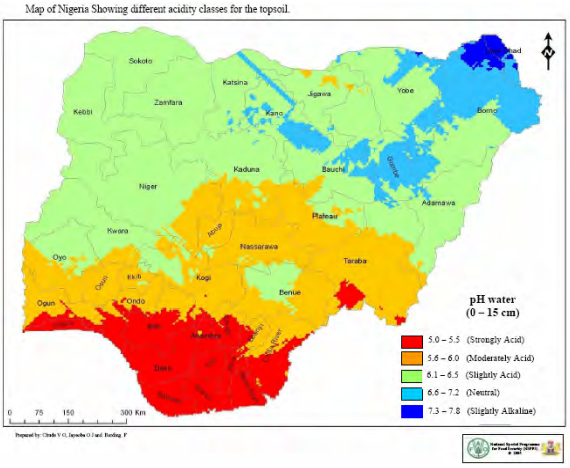




Map of Nigeria Showing different Organic carbon fertility classes for the topsoil.



Map of Nigeria Showing different acidity classes for the topsoil.



Other considerations include the following:

- Organic C is moderate to low (0.4-1.4)
- CEC is low (7.01-10 C.Mol/kg)
- pH slightly acidic to moderately acidic at pH >5-6>6.5
- Supplements to mineral fertilizer are crop residue, animal manure as fertilizer, and green manure.

D. Current Recommendation in All States

The current recommendation in all states is 4 bags of NPK15-15-15 and 3 bags of urea.

4 bags of NPK15-15-15

=15/100 *200

=30kgN, 30kg P_2O_5, 30kgK_2O, this is expressed below as 76N 30P 30K or simplified 76 30 30.

There is often confusion between fertilizer product and actual nutrient in the product. An example of calculating nutrient based on product follows: 3 bags of urea each bag weighing 50kg of product and having 23.5 Kg of nutrient N which give a total of 46kgN. On a Macro scale, this fundamental difference can be even more deceptive. A million tons of fertilizer equals 640,000 tons of nutrient if it is DAP (18:46:0) and 180,000 nutrient tons if it is 18% SSP, these being both P fertilizers.

The ramifications of cost are apparent given transport, storage, and application. The logistical cost (transport-sea and domestic, storage and application) for the P in SSP in comparison to DAP is 2.5 times more. Furthermore, there is an additional 18%N resulting in 3.5 times more logistical efficiency in DAP as per total nutrient.

Returning to the total nutrient ratio and nutrient to be applied resulting from the official recommendation given above of N P_2O_5 K_2O results in a fertilizer ratio of 2.5:1:1 based on recommending nutrient application of 76kgN 30 P 30 K or 76 30 30 This is <u>neither</u> the crop nor the soil requirement.

MARKETS recommendations should be the following, which is significantly different:

- Fertilizer grade/nutrient – 64kgN :16kgP :30kgK. Simplified: 64 16 30
- Fertilizer ratio – 4:1:2

The above ratio can be used for MARKETS' field demonstrations.

D1. Kano State

OC Low – 0.4-0.1

pH – Slightly acidic

Nutrient	Fertility Class	Recommendation
N	Average low (75% of state) West – very low (0.05)% East – moderate (0.1-1.5)% Central & north – very low (.05-.1)%	Full dose of N: 64kg N/ha
P	East – moderate (7-10) mg/kg North – high (>20) mg/kg South – high (>20) mg/kg West – high (>20) mg/kg	30 kg $K_2$0/ha
K	Low (95% of state, 0.21-0.3) cmol/kg Northeast – very low (0.1-0.2, 5% of state) cmol/kg	6kgP_2O_5/ha
K reserve	Moderate-low (0.31-0.6) cmol/kg	

Recommendations include:

- Fertilizer grade **–** 64:16:30
- Fertilizer ratio – 4:1:2

The above ratio can be used for MARKETS' field demonstrations.

Other recommendations include the following:

- Organic carbon is low (0.4-1.0)
- pH slightly acidic (6.1-6.5)
- SW, NE, SE Neutral (6.6-7.2)
- Ca: Low – Topsoil and sub-soil (2.0-5.0) cmol/kg
- B: Low (0.8- 1.99) mg/kg
- Zn: Low (1.5-3.99) mg/kg
- Mg: Moderate (1-3.0) mg/kg
- Central Kano: Low (0.3-1.0)
- Cation Exchange Capacity (CEC): Very low (2.72-5.0) to low (5.01-7)

Agro-ecology: Subhumid to dry subhumid

D2. Katsina

Nutrient	Fertility Class	Recommendation
N	Very low (0.03-0.05)%	64kg N/ha
P	High (greater than 20mg/kg)	16kgP_2 O_5/ha (because of P sorption capacity)
K	Low (0.21-0.3) cmol/kg	cmol/kg 30kgK_2O/ha
K reserve	80% of the site is low while 20% is very low	

Recommendations include:

- Fertility grade – 64:16:30
- Fertility ratio – 4:1:2 (without P addition, the grade is 64-0-30 and the ratio is 2-0-1)

The above ratio can be used for MARKETS' field demonstrations.

D3. Bauchi

Nutrient	Fertility Class	Recommendation
N	Central – Moderately high (10% of state) (0.21-0.24) %	16kgN/ha
	Medium – (90% of state) (0.16-0.2) %	32kgN/ha
	Fringes – Moderately low (0.11-0.15) %	64kgN/ha
P	Northwest – Moderate (7-20) mg/kg	16kgP_2O_5/ha
	Low – (66% of state) (3-7) mg/kg	32kg P_2O_5/ha
K	North/NW – Low (0.21-0.3) cmol/kg	30kg$K_2$0/ha
	South/southeast – (0.31-0.6) cmol/kg	15K_2O/ha
K reserve	West, south – Moderate (0.31-0.6) cmol/kg	
	Central – Low (0.21-0.3) cmol/kg	
	North – Very low (0.06-0.2) cmol/kg	

E. Three Recommendations Suitable for MARKETS' Field Demonstrations

	Fertilizer Rate	Fertilizer Ratio	Possible Compound Fertilizer to Use
Low	64:32:30	2:1:1	(20:10:10)
Moderate	32:16:15	2:1:1	(20:10:10)
High	16:16:15	1:1:1	(NPK 15-15-15) (a situation where 15-15-15 may be appropriate)

F. Two Recommendations Suitable for MARKETS' Field Demonstrations

	Fertilizer Rate	Fertilizer Ratio
Low	64:32:30	2:1:1
Moderate	48:16:16	3:1:1

Nasarawa (Keffi & Akwanga)

Slightly acidic	N is low (0.06-0.1)	P is high >20	Dry sub-humid (6.1-6.5)
Slightly acidic	N is low (0.06-0.1)	P is low 3.7	Dry sub-humid (6.1-6.5)

G. Summary of Issues Connected to K Availability and High Analysis Fertilizers

The FAO soil fertility map groups the alliance states result in recommendations that are still frequently "blanket," at least for K. The problem with blanket recommendations is that the soil geology and nutrient reserve is not considered. Two different sites can have the same soil test level and applying the same fertilizer may meet the requirement of the crop for that season. However, if the soils have different nutrient reserves, subsequent cropping may not be sustained at the same level of nutrient application.

For example, if recommendations are based on the single element K, the Oyo-Basement Complex has a K reserve in the central and northern part of Nigeria. Lagos, Ogun, and Edo

states are sedimentary. Hence, over time the same fertilizer recommendations will not work for two sites listed above based on present nutrient levels and needs such that the northern site will be more sustainable at existing levels while the southern site will be depleted and need additional levels of fertilizer and different management practices.

Following are the critical soil parameters to use for diagnoses:

1. K reserve (subsoil K) and parent material.
2. Organic matter level. If low, include crop culture of management of above-ground biomass. Add through manure, live mulch, or tree species.
3. Careful land clearing and tillage, targeting appropriate timing of plowing, etc.
4. Use of Organo, mineral fertilizer.
5. Crop rotation, fallow cropping: legumes, farming systems that keep ground cover throughout the year.
6. Avoid 15-15-15. (The following soil parameters are the principal considerations for fertility recommendations and must be part of routine analysis: pH, OM, CEC soil texture, particularly clay, sand, silt clay).
7. Minimum tillage.
8. Appropriate high analysis fertilizers that meet other needs other than NPK, e.g., mono ammonium phosphate (MAP) and DAP combined with urea, sulfates, and magnesium particularly in Guinea and Sudan Savanna ecologies. One fertilizer type presently not in the market is useful: sulfate of potash magnesia. It can be combined with MAP or DAP to add sulfur and magnesium.

While noting the potassium deficiency in the areas covered by MARKETS' out-growers as indicated by the FAO map, a 2004 high analysis fertilizer study by USAID-DAMINA and SG 2000 in four northern states (Kano, Bauchi, Kaduna, and the FCT) indicated K sufficiency in several sites. This study based on 64 fertilizer demonstrations and 48 soil tests noted that there was a "high availability of potassium in northern Nigerian soils. The quantity of MOP was accordingly reduced and only a small quantity (7 kg/ha) was recommended for application as a readily available K20." These demonstrations on maize and rice had great success in comparing use of high analysis fertilizers DAP, urea, and MOP to 20:10:10 and the official recommendations. The main results showed that there were: 1) economic savings, 2) better stands, 3) greater yields, 4) increased biomass, and 5) a significant increase in farmer net income.

This indicates that even in regions having general K deficiency, there are soil variations and significant areas with K sufficiency and where K application can be reduced, resulting in lower costs and increased production and income.

VII. MARKETS' COWPEA LOCATIONS AND RECOMMENDATIONS

Cowpea is a protein legume that has supplied the protein requirement for a large part of the Nigerian population for decades. The major advantages of this crop are its ability to nodulate and fix a large proportion of its needed nitrogen. It therefore fits well into a highly deficient expanse or arable lands in the Northern Guinea and Sudan Savannah which are the major growing zones of cowpea.

Phosphorus and potassium nutrition become critical in cowpea, but it needs a starter dose of nitrogen. Excess supply of nitrogen will not only retard nodulation and the nitrogen fixing ability but also result in large production of leaves that delays yield and lowers crop quality.

A. Federal Fertilizer Department Recommendation

N	Low N – 20kgN	Urea 48kg, CAN 74kg, 20-10-10 100kg
	Medium –10kgN	Urea 22kg, CAN 27kg, 20-10-10 100kg
	High – Nil	Nil
P	Low – 40kgP_2O_5	SSP 222kg, TSP 89kg,
	Medium – 40kgP_2O_5	SSP 111kg, TSP 44kg
	High – Nil	Nil
K	Low – 20kgK_20	MOP 33kg
	Medium - 10 kgK_20	MOP 16kg
	High – Nil	Nil

B. Agro-ecologies Recommendations

Sahel and Sudan	20kgN	Urea 44kg CAN 74kg, 20-10-10
	400kg P_2O_5	SSP 222kg, TSP 89kg
	25kg K_20	MOP 33kg
Guinea Savannah	10kgN	Urea 22kg, CAN 37kg
	36kg P_2O_5	SSP 200kg, TSP 80kg
	20kg K_20	MOP 33kg

In the rotation from cereal test soil, the residue effect of grains may suffice for the cowpea.

C. Recommendation per MARKETS' Cowpea Logistical Fix

C1. Kaduna

N	Northwest – Very low (0.03-0.05) % Other parts – Low (0.03-0.1)	20kgN/ha
P	All parts – High (>20) mg/kg	0kg P_2O_5/ha
K K Reserve	North & northeast – Low (0.21-0.3)cmol/kg Northwest & southwest – Moderate (0.31-0.6) cmol/kg Low to moderate	20kg K_20/ha 10kg K_20/ha

Recommendations include:

- Fertilizer grade **–** 20-0-20 or 20-0-10
- Fertilizer Ratio **–** 2:0:2 or 2:0:1

The above ratio can be used for MARKETS' field demonstrations.

C2. Kano

N	West & north – Very low (0.03-0.05) % North central, south – Low (0.06-0.1)% East – Moderately low (0.11-0.15)%	20kgN/ha
P	North central & southwest – High (>20) mg/kg East – Moderate (7-20 mg/kg)	0kg P_2O_5/ha 20kg P_2O_5/ha
K K Reserve	98% of state – low (0.21-0.3) cmol/kg 2% located in the east (0.12-0.2) cmol/kg Moderate (0.31-0.6) cmol/ kg	20kg K_20/ha

Recommendations include:

- Fertilizer grade – 20-0-20 or 20-20-20
- Fertilizer ratio – 2:0:2 or 2:2:2

The above ratio can be used for MARKETS' field demonstrations.

VIII. GENERAL RECOMMENDATIONS FOR TEST CROPS

A. Essentiality of Nutrients in the Recommendations

There are 16 essential elements, 3 of which are naturally supplied while the remaining 13 may be supplied with mineral fertilizers. Currently, the focus has been on the primary elements NPK; in most of the crops the assumption is that the needs fall in the order: N > P > K (not N=P=K.)

While this is so in theory, in practice and with the intervention of different environmental impacts and variability, the assumption will need to be modified even though it is the most basic parameter.

Micro nutrients are also essential. If they are not adequate in the native soil and are not added in the mineral form as fertilizers, alternative means need to be considered. Since the soil is the main medium of crop production, soil limitations arising from the different agro-ecologies is therefore a major budget concern for crop production. An alternative source of nutrients is organic matter (OM. OM, whether native or added as manure, is a storehouse of nutrients and is positively correlated with N, P, K S, CEC, and other exchangeable Cations and micronutrients.

Organic matter, therefore, becomes the coefficient of continuous cropping and conventional nutrient utilization and management. Unfortunately, in all the locations in the Guinea and Sudan Savanna where USAID-MARKETS operate, there is low level of organic matter. There the project is dealing with a marginally low fertility soil in terms of N and management becomes an important issue.

Agro ecology influences soil release and conservation of the meager nutrient reserve in tropical soil. Soil pH is affected by rainfall and, in turn, time of planting fertilizer application and its use efficiencies.

B. The Test Crops

Essentiality (or priority soil factor) for each test crop is important in soil management for sustainable crop production.

1. *Sorghum (N,P)*. While K is important, it does not form the structural frame of the plant. Furthermore, it is mobile and moves from plant to soil after crop maturity, behaving like an AUXIN. This makes K fertility evaluation and recommendation tricky. Soil may test low, but after application of K there is no response. Why? This as an area of research at zonal levels. Crop utilization and response to K behaviors also differ.

2. *Rice*. The levels of primary nutrient need is: N>P>K. in lowland rice. The reducing conditions and iron mobilization affect P fixation, and low K affects grain feeling and water potential.

3. *Cowpea/soybean*. P:K ratio is critical. Nitrogen is needed only as a basal application since cowpea nodulates and fixes its own N. In addition, excessive mineral N fertilizer delays maturity.

Comparative effectiveness of some compound fertilizer formulations were evaluated in two ecological zones. The use of NPK 15-15-15 caused P and K accumulation in the soil and resulted in P/Zn and Mg/K imbalances in plant leaf tissues. NPK 15-15-15 with ratios 1:1:1 was supplied to crops in equal amounts of N, P, and K and therefore possible P and K in excess of the recommendation for maize, which was the test crop. Higher N grades (20-10-10, 25-10-10, 27-13-13) did not exhibit imbalances and excesses. Fertilizer use efficiencies varied with fertilizer types: NPK15-15-15 <20-10-10 2S 1Zn <25-10-10 <27-13-13. N/P balance was found to be critical to optimum yield and yield quality.

Straight fertilizers or high analysis fertilizers can be used flexibly but applied without thought to nutrient ratios can be as inefficient as fixed NPKs. However, the Damina studies showed that it can have better results and farmers are capable of applying them in efficient ratios at less cost per nutrient.

There is need for a review of the nutrient ratios of different formulations that are suitable for or address different soils and crops in defined agro ecologies. Such a review will take time but can be done as long as there is cooperation among all stakeholders in the Nigerian agrarian system.

	Fertility Class	Recommendation
N	North – Low (0.06-0.1)%	64kgN/ha (urea 142kg)
	South – Moderately low (0.11-0.15)%	48kgN/ha (urea 106kg)
P	North – High (>20) mg/kg	Nil (SSP 89kg)
	South – Moderate (7-20) mg/kg	16kgP_2O_5/ha (TSP 38kg)
K	North – Moderate (0.31-0.6)cmol/kg	15kgK_2O/ha (MOP 25kg)

Following are two recommendations factoring in P adequacy:

	Fertilizer Rate	Fertilizer Ratio
Moderate	64:0:15	4:0:1
Low	64:16:15	4:1:1

C. Summary

For the different states using the current fertility maps for sorghum, the following fertilizer recommendations and grades have emerged:

	Fertilizer Rate	Fertilizer Ratio
Kaduna	64:16:30	4:1:2
Kano	64:16:30	4:1:2
Bauchi	64:32:30	2:1:1
	32:16:15	2:1:1
	16:16:16	1:1:1
Plateau	64:32:32	2:1:1
	48:16:16	3:1:1
Nasarawa	64:0:15	4:0:1
	64:16:15	4:1:1

IX. MARKETS' SOIL FERTILITY ASSESSMENT RESOURCES

A. FAO Fertility Map: Its Strengths and Limitations

Although a fertility map is a useful guide for fertility evaluation, a holistic approach is needed to arrive at meaningful diagnoses and recommendations.

Our focus has been on phosphorus and potassium, but N, pH, OC must also be considered in the recommendation, particularly when the states in which MARKETS is working in sorghum and cowpea have a potassium shortage, with surprisingly adequate phosphorus in both topsoil and subsoil.

This means that the potassium problem and its waste in NPK formulations and applications *also includes waste in phosphorus*, which is a more expensive nutrient and likely used more than potassium. The loss to farmers by overdosing in either of these is enormous and underscores the need for a new strategy based on primary dependence for nitrogen from urea produced by Notore Chemical Industries at Onne Rivers state combined with a careful determination of the real basal dressing requirements according to soil and crop.

There are many challenges to sampling soils, such as lack of facilities and logistics problems such as transportation and labor. A state-by-state soil testing program needs to be conducted. With the availability of GIS, modern techniques should be used to go beyond the soil fertility map to evaluate *soil capability and suitability* and develop calibration curves for each of USAID MARKETS' mandated crop in each state/local government. Moving to this level of evaluation is essential to achieving a true agrarian revolution, improvement in food security, and environmental conservation.

FAO Fertility Map Sampling Sites

States	# Sampling Sites
Sokoto	2
Kebbi	4
Zamfara	2
Niger	24
Kwara	5
Kogi	11
Oyo	16
Oshun	5
Ogun	7
Lagos	2
Ondo	4
Ekiti	None
Edo	12
Delta	None
Bayelsa	1
Rivers	14
Imo	3
Abia	5
Akwa Ibom	6
Ebonyi	9
Cross River	11
Enugu	5
Abuja	2
Nasarawa	3
Kaduna	33
Katsina	7
Kano	8
Jigawa	3
Bauchi	19
Plateau	14
Benue	18
Gombe	3
Yobe	21
Borrno	1
Adamawa	18
Taraba	24
Total	**343**

The current system results in a colossal waste of scarce fertilizer investment because the soil is not well prepared to be the custodian of the nutrients for root interception within its short lifespan of arable cropping. This is now seen to extend beyond potassium to phosphorus. The cost implications to the Nigerian agricultural economy are enormous.

B. MARKETS' Soil Testing Capability: 200 Mobile LaMotte Field Soil Tests

MARKETS, in anticipation of the need to test soils where demonstrations are to be carried out, purchased two La Motte Field Soil Test Kits. Selection of La Motte was based on the fact that it had been tested in Nigeria for an academic thesis, an abstract of which will be given below. Since there is a local franchise in Nigeria for the La Motte kits any demonstration effect and demand as per mobile soil testing kits could be supplied locally.

LaMotte Soil Testing Kit Capability pH, N, P, and K as tested in Nigeria. Taken from E.Y. Thomas, "An Evaluation of the Conventional Methods of Soil Analysis and the LAMOTTE Kit'' University of Ibadan, 2004 with the author's permission.

ABSTRACT

Soil nutrient depletion in farmers' fields is recognized as a causal force leading to chronic food insecurity and rural poverty in Africa. Soil testing, which is an important management tool required for maintaining a chemical and microbiological balance within the soil, should therefore be practiced. The conventional methods of soil analysis employ the use of sophisticated and expensive equipment which many times are beyond the farmer's reach.

There is need to investigate a cheaper and handy source of nutrient analysis in soil by chemical methods other than the conventional method. This project was therefore designed to evaluate the conventional methods of soil analysis and the LaMotte kit for quick test. The LaMotte kit system method is a modern soil testing method involving the use of colorimetric chemical reactions. Thirty-three soil samples from different parts of Nigeria were subjected to the conventional and LaMotte kit methods of soil analysis. The pH, phosphorus, potassium, and nitrogen were determined.

The results of the correlation coefficient indicate a high degree of association between the two methods, with pH being highest at 99 percent, potassium at 96 percent,

phosphorus at 93 percent, and the least, nitrogen, at 80 percent. The coefficient of determination for linear regression also shows that there is a significant linear relationship between the two methods except for nitrogen.

The use of the LaMotte kit can be a good alternative to the conventional method of soil analysis.

The LaMotte Soil Testing Kit

The LaMotte soil testing kit is common used in the developed countries. The kit comes in a portable box, which houses the reagent for each element to be analyzed. Other apparatus in the box are different types and sizes of test tubes, color chart, universal extractant, measuring spoon, indicators, sample tubes, string rod, funnels, spot plates, filter paper, etc. The kit has accurate analysis for pH, nitrogen, phosphorus, and potassium. The principle of the La Motte soil testing kit is colorimetric, which involves color development. These colors are compared with standard color charts to give the readings. Nutrient deficiency is identified quickly and it provides accurate, easy-to-read results in minutes. (Bio control Network, 2003). The kit can be used on the farm while conventional equipment cannot be easily carried to the field. In the field, testing provides the users with immediate answers to nutrient problems.

Soil Extraction Procedure

The universal extracting solution (5173) is composed of sodium acetate which has been adjusted to a pH of 4.8 with acetic acid. This solution extracts the soluble nutrients, such as phosphorus and nitrogen, as well as soluble and exchangeable potassium and other cations, such as calcium and magnesium.

Potassium Test

The potassium test is based on the fact that potassium salts give a yellow crystalline precipitate with sodium cobalt nitrate, potassium reagents B (5161). Potassium reagent C (5162) is denatured ethyl alcohol, which facilitates the formation of the precipitate in more or less colloidal form.

Phosphorus Test

Phosphates react with ammonium molybdate, phosphorus test reagent # 2 (5156), to produce salt of a complex ammonium phosphomolybdate, which produces the blue molybdenum oxide color when reduced. Phosphorus reagent # 3 (5157), the reducing agent, is stannous chloride.

Nitrate Test

The nitrate test is based on the so-called Denige's test in which two dye intermediates are coupled in the di-azo reaction to form a color dyestuff. The nitrate required in this reaction is supplied by reduction of the nitrate in the soil extract. Nitrate test reagent #1 (5147) is a solution of potassium acid sulphate. Nitrate reagent #2 (5147) is a mixture of the two intermediates, N (1-naphthyl) - ethylene diamine dihydrochloride and sulfanilamide; the reducing agent, which is Zinc dust; and the filler, which is barium sulfate.

Location of Samples

Soil samples were collected from various locations in Nigeria, samples 1 and 2 were collected from Nsukka, sample 3 was collected from Kano, and samples 4 and 5 were collected from Ibadan (IITA). Samples 6-9 were from Maraba farm in Yobe state, samples 10-13 from LOC–Fika farm Yobe state. Samples 14-17 came from Kaifin Madaki in Bauchi state. Samples 18, 19, 22-23 came from Aliada in Benue stat, and samples 20-21, 24 & 25 were from Cross-River state. Samples 26-27 were from Ikogosi Alawaye farm in Ekiti state, sample 28-29 also came from Ikogosi Ijoko farm in the same state, and samples 30-33 were collected from Binrin Yauri from Kebbi state, for a total of 33 samples.

Sample Preparation

The soil samples are collected in polythene materials or bags to avoid contamination. They are then spread on polythene or plastic materials in the laboratory to air dry. The soil samples are then grounded and sieved and packed in the polythene material for storage before analysis.

LaMotte Method of Soil Analysis

The La Motte kit used is the model STH – outfit (code 5029) test for soil pH, nitrate nitrogen, phosphorus and potassium. Standardized color charts are used for the entire test except potassium. The potassium measures the amount of turbidity in a sample relative to the potassium content.

X. CONCLUSIONS

A. General Comments

This project's attempts to make fertilizer recommendations based on the FAO (2005) fertility map for sorghum and cowpea outgrowers in several northern states (across a variety of agro-ecologies) have been revealing and useful.

Given the high soil variability between states and even within states (e.g., Kaduna), blanket or generic fertilizer recommendations are contrary to the reality of crop and soil nutrient requirements. The current FAO (2005) fertility maps should be used only for national indications of fertility levels, not individual farmer needs. Indeed, the farmer needs to ground truth what the national nutrient map prescribes, which can be done through soil testing. Action to create a soil testing campaign for farmers can begin to make fertilizer the technology it should be for a green revolution in Nigeria.

B. History and Observations on the FAO 2005 Map and Macro-Nutrient Overloading

Historically, maps available to Nigerian policy makers and donors supporting Nigerian fertilizer have been mineralogical or geological and have not provided the direction needed for fertilizer recommendations based on soils, crops, and the many other factors determining nutrient needs.

As an early example, in the mid 1980s, while the former National Fertilizer Company of Nigeria (NAFCON) fertilizer plant was determining what NPKs should be produced by its compound fertilizer facility, it had no fertilizer mapping instruments to determine fertilizer typing to meet needs of locations and crops. It did, however, have historical distribution records by fertilizer type and quantity to states; but this, along with technical production capacity of the factory, were the only parameters available. The predominant NPK, then as now, was 15:15:15. The International Bank for Reconstruction and Development (IBRD), through its US$ 250 million fertilizer loan, seeded in Nigeria 50,000 MT of DAP (18:46:0) in 1984 and advocated increased use of urea 46:0:0 (versus calcium ammonium nitrate [CAN]) to try to increase nutrient content (both high analysis fertilizers) in product as well as shift the national NPK ratio. The latter did not follow the normative N>P>K because of the predominant use of SSP (16-20% P), 15:15:15, and CAN (20-26% N).

The preponderance of low analysis fertilizers has remained with Nigeria. Existing NPKs as basals have serious limitations and while the acceptance of urea has been achieved, the original concept of using DAP as a basal has been lost. DAP is an excellent basal as it contains a small amount of N needed after seeding and the P20 required. If there is a K deficiency, application of MOP (0:0:60) makes sense economically and allows the flexibility to get the K in the right ratio. The DAIMINA/SG 2000 conducted in 2004 field trials demonstrated this and also showed that farmers can do this on their own once they know their soil's nutrient requirements.

NAFCON at that time was concerned with overloading of K. It held discussions with IAR, NCRI, and UNN to use existing soil data to draw up fertility status maps similar to those published by the Fertilizer Association of India (FAI). However, this map was never finished. Twenty years later, the FAO map meets a long-held need, despite its limitations.

B1. "K "

The project was initially interested in the possible overdosing of K because of the NAFCON concern from 20 years ago. Perusing the maps, it is clear that while there are many areas deficient in K, a large portion of the country has moderate to high potassium in the topsoil, notably in the central middle belt (including all of Benue, Kogi, and Nasarawa, FCT and half of Plateau states) and central north, the latter including much of Kaduna. Bornu is moderate in approximately half the state. This topsoil map shows Kano, a major fertilizer consumer, as low, but in the subsoil map this state has K in moderate amounts. The above-described area consumes the largest portion of fertilizer and NPKs nationally. Therefore, the general use of 15:15:15 in this region can be seen as undoubtedly in excess. Even a 2:1:1 ratio seems excessive.

B2. "P"

The overloading of P, a more expensive nutrient than K, was a surprise result of this study. It has far-reaching implications for future NPKs, and this with the K excess reflects sadly on fertilizer use of the last 25 years. A large swath of Nigeria's highest consuming agricultural land shows high or moderate presence of P, including the largest consuming states of Kano and Kaduna. Most of Kaduna as well as a large portion of Nasarawa is actually high in P.

B3. “NPKs”

Based on further analysis and observation of the map, fertilizer need of soils is rarely in a ratio of 1-1-1. This has a far reaching implication on the long popular and readily available fertilizer grade NPK 15-15-15. The soil map reveals an overloading of P even more than K depending on the soil and zone. It should be noted that while new blends such as 20:10:10 and 27:13:13 are available, these are still well off the mark in many places.

There should be a reconsideration of other grades where the soils are affected. This was the direction of thought of the national technical committee on fertilizers when the recommended alternative blends and grades, i.e., 20-10-10, 12-12-17-2MgO etc., were made. This effort should continue, and perhaps move more radically. Note that some of the recommendations made as total NPK ratios in this paper are: 4:0:1, 4:1:1, 2:0:2.

In fact, using some existing recommendations such as 2:1:1 ratio (while appropriate for maize) virtually preclude use of urea as a top dressing in sorghum production (as per recommended package of practices). Actual practice is seen to be moving to a one-time application around time of seeding. The N dose is too high for a one-time initial application, and a top dressing of N is required later in the cropping season. The IBRD introduced DAP as a starter fertilizer, though now it is primarily used in bulk blending fertilizers with urea and MOP.

The problem reflects the failure to effectively utilize high analysis “single fertilizers” such as urea, DAP, and MOP. In retrospect, the extension advice and what little fertilizer type development occurred over the years seems now to have been regressive and perhaps patronizing, reflecting low expectations of farmers.

Mineral fertilizer alone cannot fulfill the demands of a sustainable green revolution. An integrated Organo-mineral fertilizer regime and cultural management of crop residues must go with adequate soil test recommendations. Mucuna or related green manure should come into fallow cropping to enhance sustainability of productivity. Efficiency of chemical fertilizer will then be assured.

C. The Soil and its Knowledge

Soil testing. Given soil variability and other factors, soil testing should become an urgent national goal.

Soil testing is an important management tool for maintaining a chemical, physical, and biological balance and assessment of inherent fertility. Historically, few if any of the large-scale arable farms that were established without a soil testing program survived.

Yet farmers have not been convinced of the need for soil testing. This is not related to the Nigerian farmers' willingness to adopt new practices. A recent MARKETS' baseline study conducted in August 2006 noted that farmers in 19 states generally have adopted fertilizer and other green revolution technology at high levels. Why not soil testing, particularly for those larger scale farmers who are more progressive? This knowledge becomes an investment in the future, saving production costs year after year.

It is noted that while conventional soil testing laboratories often do not release results early enough for farmer's use during the cropping season, there is still a need to move systematically on tests. Based on quotes by a university soil laboratory, the cost for one partial test would be 6,000 Naira, or the equivalent of US$ 46. However, if a thousand partial tests are taken, the cost could be reduced to 500 Naira, or a reduction of more than 80 percent. Thus, a cost of Naira 500,000 or about US$ 4,000 per thousand tests is established. This has implications for a national soil testing campaign.

To provide another perspective, using a model with conservative estimates of 1 million MT fertilizer product consumed nationally, and using 2006 Lagos landed costs for NPK (15:15:15) and urea, and assuming a 60:40 ratio of NPK:urea, total procurement cost to the country would be about US$ 280 million. Soil testing of a 100,000 samples would be US$ 400,000, and a million samples US$ 4 million.

An investment in soil testing at either level could radically correct the present nutrient imbalances. The cost of a soil testing campaign at the 100,000-sample level would be paltry compared with the total fertilizer cost for a year: procurement plus transport, marketing, and farmer's application labor. Once completed and acted upon by the scientific authorities, the savings could be in the neighborhood of millions of U.S. dollars yearly. More importantly, the savings from not overdosing and wasting nutrients could be applied to increased quantities of fertilizer providing those nutrients truly needed, increasing production and income and revenue to farmers and the entire agricultural economy. A side benefit to such a campaign would be empowering the well educated scientists in the

country to apply fully their knowledge in this area. These scientists are located throughout the nation.

D. Alternatives to Conventional Laboratory Testing

MARKETS procured two soil test kits assuming the availability of soil data might be a constraint in assessing soils. The La Motte soil testing kit had been tested in Nigeria in several locations so it was selected. While MARKETS' soil testing capability is limited, there is no doubt it will be useful for the project's targeted farmers in selected locations. Test kits are particularly appropriate for rapid evaluation of soil nutrients in a farmer's field. It fits into the concept of a mobile laboratory. The concept of soil testing kits adopted worldwide in the developing context is appropriate technology for Nigeria.

Soil kits are not only useful for soil analysis in situ, but also in training farmers to be discerning in their outlook on fertilizer application.

Estimated equipment and reagent cost per test is approximately US$ 5. At this price, the per-thousand test cost would be about US$ 5,000. This cost cannot be reduced by the same percentage as is possible by conventional laboratories, but it has the advantage of mobility and is within the ability of service providers such as input dealers to purchase and perform on farmers' fields.

Note these costs do not apply to the FAO study, which was full testing of all variables and included institutional costs of program and its management.

E. Actions Needed Now by Stakeholders

E1. Government and Public Institutions

Economically, the current fertility map shows colossal waste through nutrient imbalances. There is urgent need to correct the error before further investment continues based on the wrong fertilizer premise. To give an idea, a simple back-of-the-envelope calculation based on conservative estimates of waste indicates that Kano and Kaduna lost about US$ 1.5 million in 2005 alone due to overdosing nutrients where they were not needed. This is based on estimates of fertilizer receipts to these states in 2005 using 2006 prices of landed cost of product and transport alone. This calculation does not include marketing and valuation of farmers' work in application.

Thus, there is potential for tremendous savings to the government and Nigerian agriculture based on the cost of some knowledge.

At the national level, the greatest “fertilizer-soil” subsidy that a farmer needs is to identify the capability and suitability of his soil. This should be given at token to farmers as knowledge to help them reduce costs by purchasing appropriate fertilizers as well as to teach them the importance of soil testing. Fewer costs means improved income.

Recommendations for actions by government:

1. Movement by the national fertilizer technical committee to consider more fertilizer types of basal dressing. The committee should take up the issue of DAP and MOP as directly applied fertilizers by farmers using the example of the Asian “Green Revolution.”

2. “Nationalize” existing data on soil tests from all laboratories supported by the government and use it to compile a more comprehensive fertility map.

3. Divert some of the subsidy funding presently given by government for fertilizer and allocate it to soil testing for recommendations or subsidized soil testing by institutional laboratories. Conduct a *Nigerian National Soil Testing Campaign (NNSTC)* involving universities, research institutes, government agencies (Ministry of Agriculture, fertilizer division), Environment Raw Materials Research and Development Council FAO, ADPs, fertilizer blending companies, state and local government, and international donor organizations.

4. Target fertilizer subsidies to farmers incorporating fertilizer recommendations and using more market-smart and farmer-friendly approaches to subsidization. The present system is distortive and, worse, inculcates deleterious and destructive behavior by market participants. An example of alternatives is the voucher system successfully demonstrated in country and addressed at the Africa Fertilizer Summit.

E2. Donors and Projects

FAO has taken the lead in what donors can and should do. USAID MARKETS, by investing in this study and taking care to be self-sufficient in soil testing for its farmer clients, is providing examples of what donor projects can do. The 2004 USAID-DAIMINA/SG 2000 high analysis fertilizer demonstrations are another example of how projects can take initiative in nutrient awareness by farmers. Programs focusing on bringing about production increases should have a soil testing component in their project.

It is hard to understand why the entire Integrated Rural Development Program of IBRD with its constituents of FACU/PCU, APMEPU, and the ADPs never developed this capacity nor thought to incorporate it in ADP commercial services units or supply companies and, for more than 25 years made blanket fertilizer recommendations in every state in Nigeria without this knowledge. The IBRD fertilizer loan of the early 1980s, which was controversial within IBRD, is vindicated in some part, not only because fertilizer distribution was efficient under the program (note the Financial Times, Nigeria Supplement of 1985), but also because without the specific fertility data, it tried to rebalance the national N:P:K ratio through introduction of DAP and urea.

E3. Agricultural Input Dealers

The USAID effort and commitment by the Federal Government of Nigeria to establish agricultural input dealer associations (AIDAs) is a new and important initiative. Governments and donors tend to create institutions within their systems to identify and provide information on the private sector. Often because of lack of knowledge of the trade and lacking the drive that accompanies entrepreneurial effort, these creations fail to serve as conceived.

The Fertilizer Association of India (FAI) offers a useful example of how trade associations can effectively work in the context of soil fertility and nutrient status and how they can be used to make fertilizer recommendations. The FAI developed simple soil nutrient status maps for the entire country (India) in the late 1970s and early 1980s. These were used as tools for hundreds of thousands of input dealers and tens of millions of farmers as guides as to the best types of fertilizer for their location. The “Green Revolution” of India is now legend and it depended on improved crop varieties, chemicals, and fertilizer. An untold story of this success is the efficiency with which Indian policy makers, fertilizer companies, input dealers, and farmers used fertilizer based on the knowledge of Indian soils.

There are presently in Nigeria fertilizer trade associations such as FEPSAN and various state AIDAs that can provide a similar role both at the national and state levels.

E4. Farmers

Nigerian farmers love their soil. They are married to it as fundamentally as they are to their spouses. They want to care for it. Twenty-five years of development efforts have made most Nigerian farmers progressive and they do adopt new technologies readily despite what some critics say, particularly after they have seen the benefit. They are also very market conscious and cost aware. They do not use soil tests because they have not been oriented to them. Sadly, their acceptance of fertilizer has been a double-edged sword. They see responses but do not know that they are probably paying too much for it or they could even apply more if the fertilizer types available to them were appropriate. The old generic fertilizer recommendations may not only have cost them more, but may have been detrimental to their soils, as described in the technical portion of this paper.

Nigerian farmers need re-orientation to this issue as well as education. Additionally, an effective and cost-efficient government subsidy to them would be knowledge of their soil.

XI. SUMMARY

This study is a direct result of the Africa Fertilizer Summit (AFS) and is meant to be a contribution to Nigeria, arising from the many efforts that made that summit a success. The valid concern raised during the summit about Africa's use of fertilizer and the deterioration of its soils based on nutrient mining catalyzed this study. Point 10 of the summit's 12-point resolution addressed the need for mapping and soil nutrient testing. Yet many of this study's findings seem to contradict the blanket urgency that was a theme of the summit. For example, there is the contradiction that while Nigeria uses little fertilizer on a kg/ha basis, it is at the same time wasting tens of thousands of tons of nutrients and probably billions of Naira through overdosing and misapplication. This contradiction really only exists because at times the approach to nutrient mining is shallow. Millions of tons of additional fertilizer is an answer; but millions of tons of additional and efficiently applied fertilizer is a better answer to Africa's soils problems.

In retrospect, it seems there is a need for a new, smarter, sharper concept of "nutrient mining." Among this study's theses is that a campaign to avoid nutrient mining does not preclude rationalization of nutrients in basal dressing. In fact, the latter will allow more of the appropriate nutrients to be applied, providing for increased production and, assuming a market, more revenue. At a minimum, it has the potential to reduce production costs to millions of Nigerian and West African farmers.

Finally, to quote Professor Adeoye:

> "MARKETS' effort on this project is a rescue operation and one pleads that the Nation and all stakeholders respond positively and objectively and act very fast to correct the trend in the spirit of 2006 Green Revolution crusade in Africa which Nigeria championed at the Africa Summit on Fertilizer."

AGROECOLOGICAL ZONES MAP OF NIGERIA
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REPUBLIC OF CAMEROON
BIGHT OF BENIN
60 0 60 120 Kilometers
National Special Programme for Food Security (NSPFS)
© 2005
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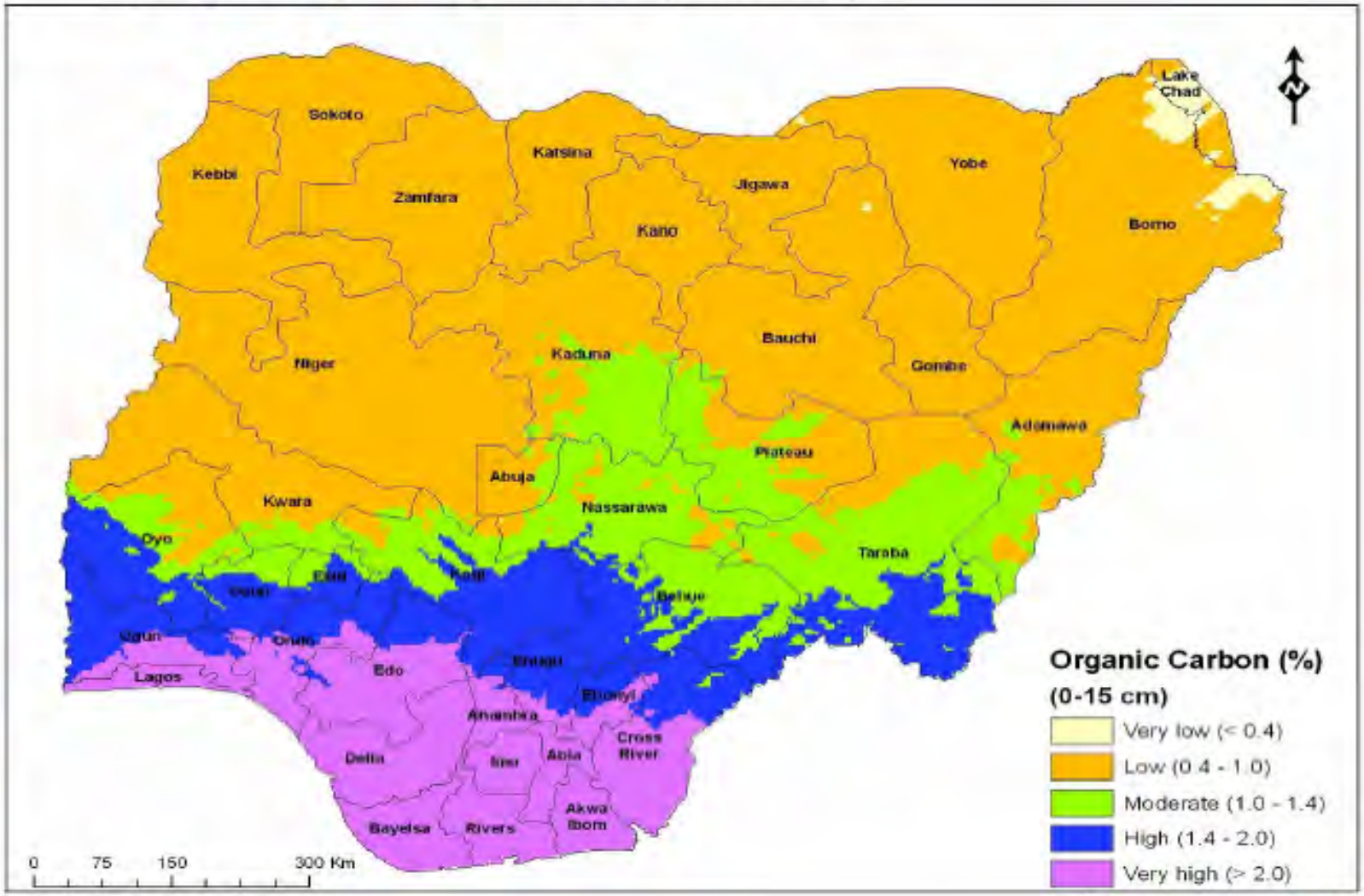
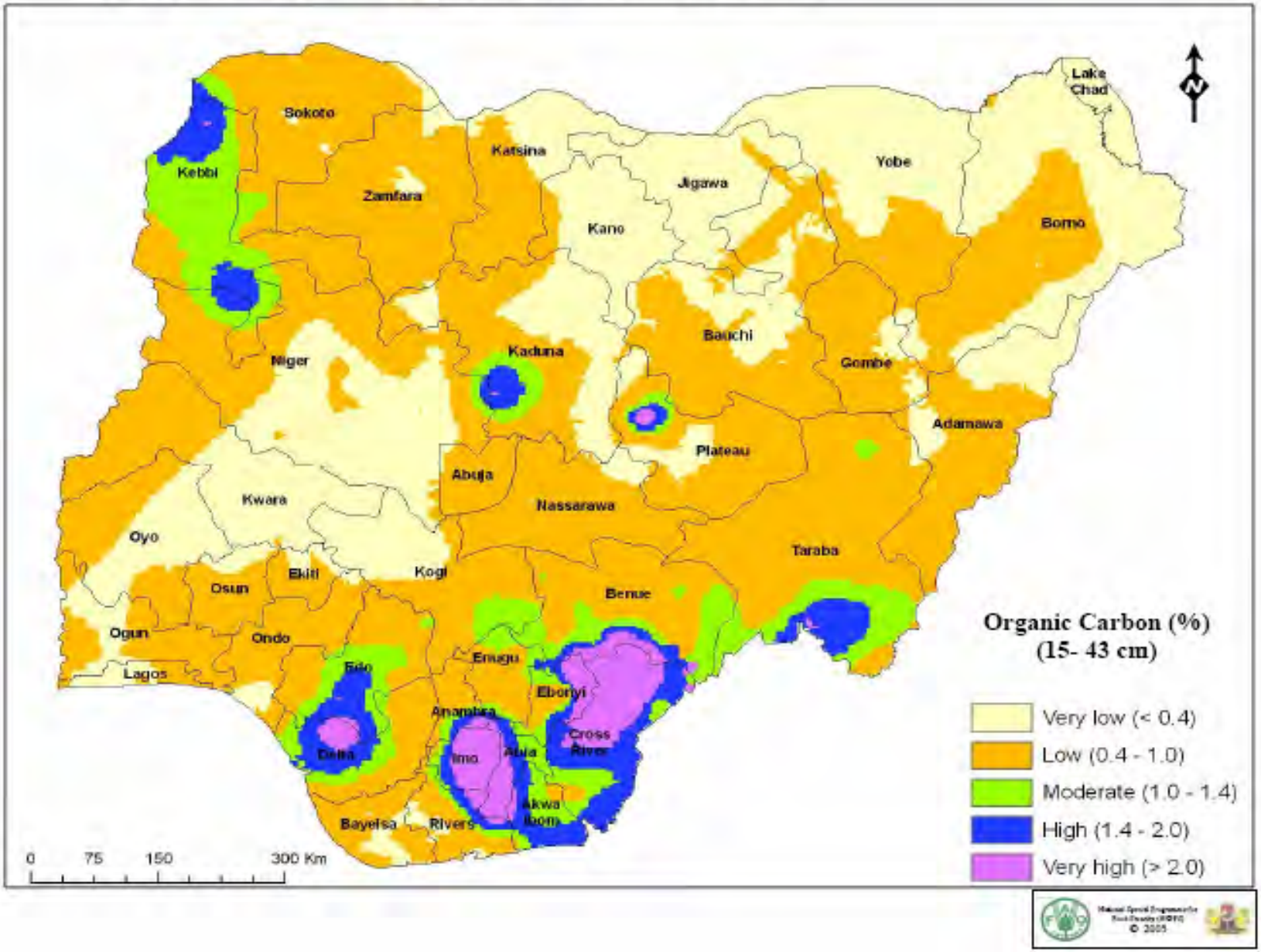
S= HUMID JOS PLATEAU

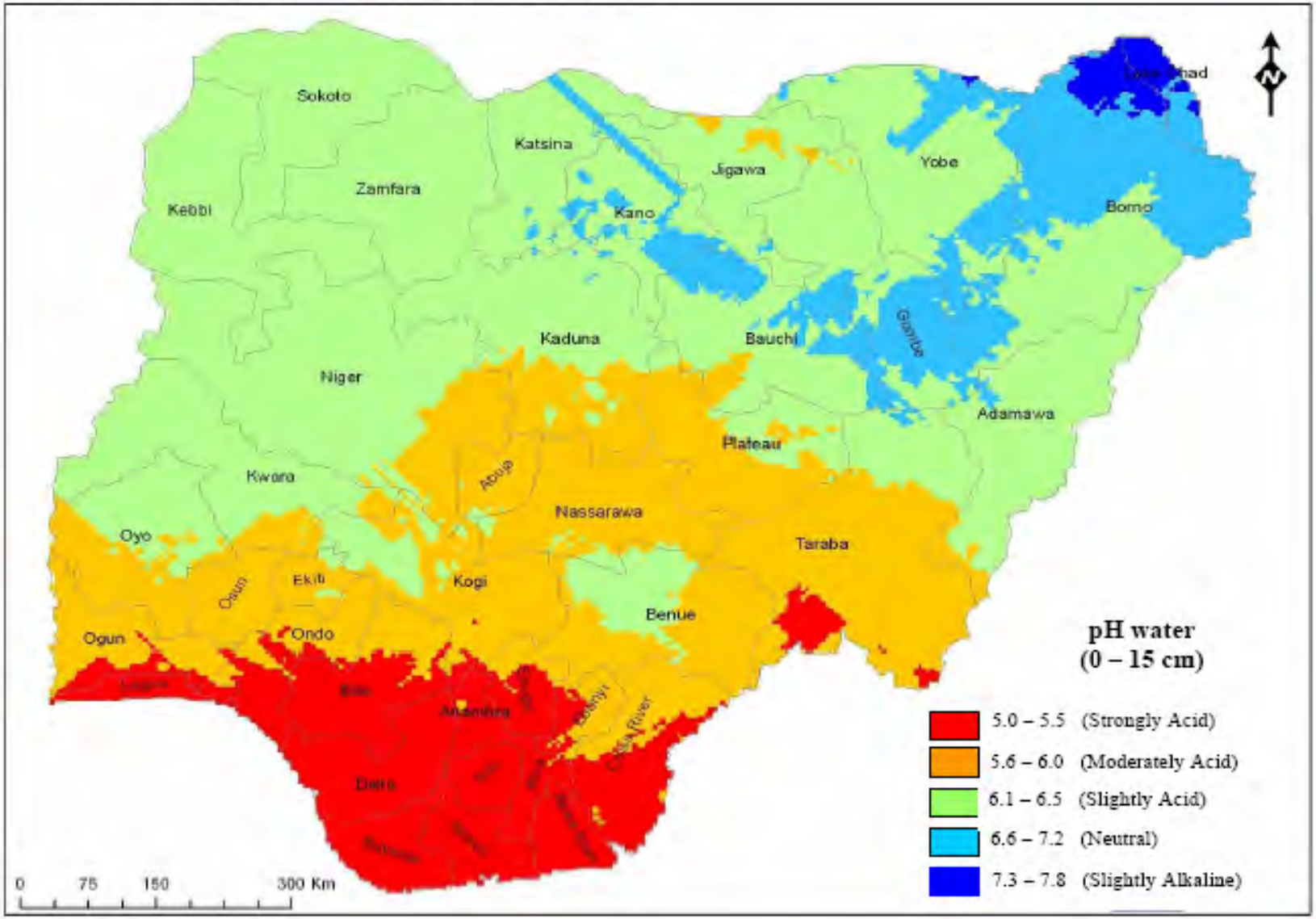
Map of Nigeria Showing different Organic carbon fertility classes for the topsoil.



Map of Nigeria Showing different Organic carbon fertility classes for the subsoil

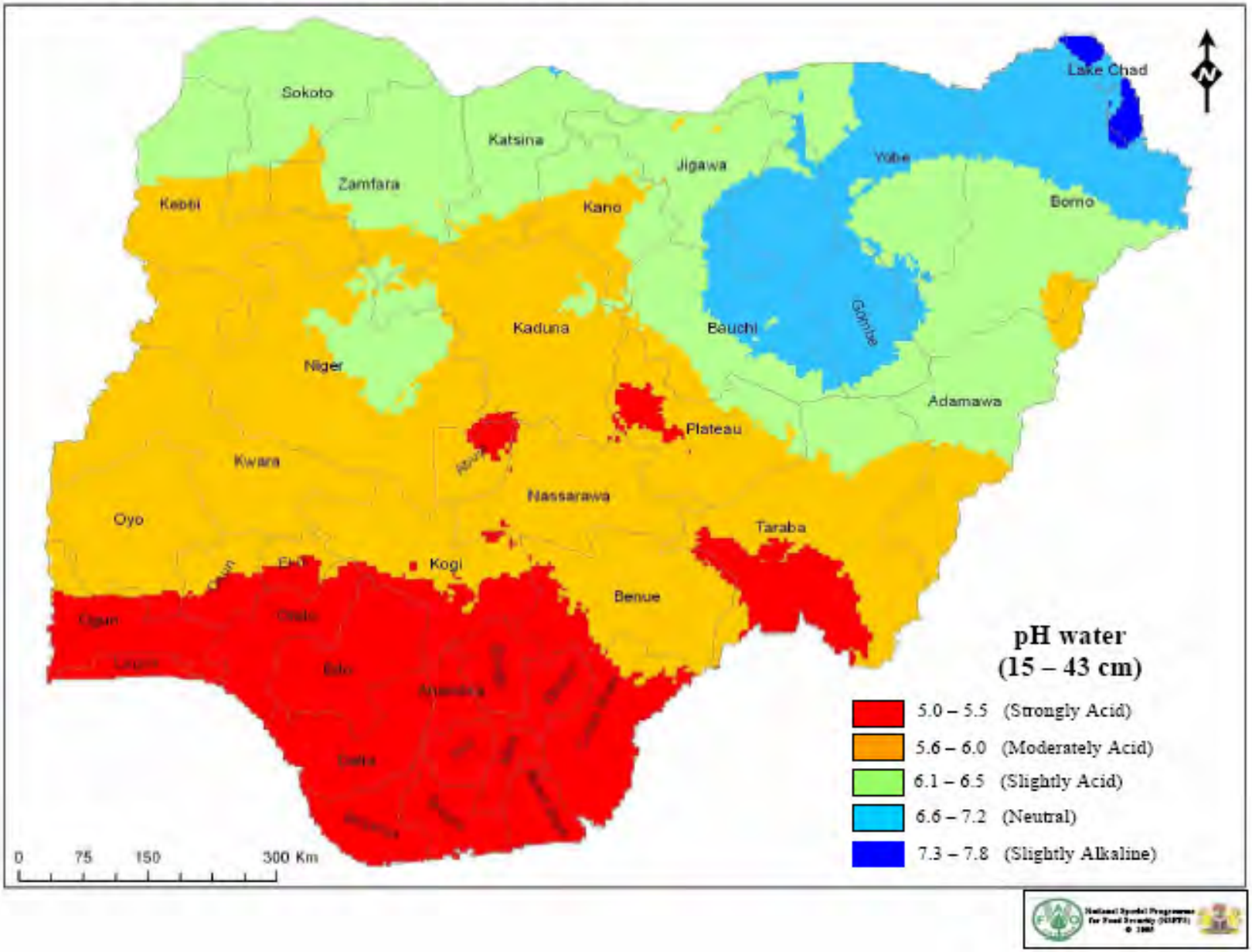


Map of Nigeria Showing different acidity classes for the topsoil.

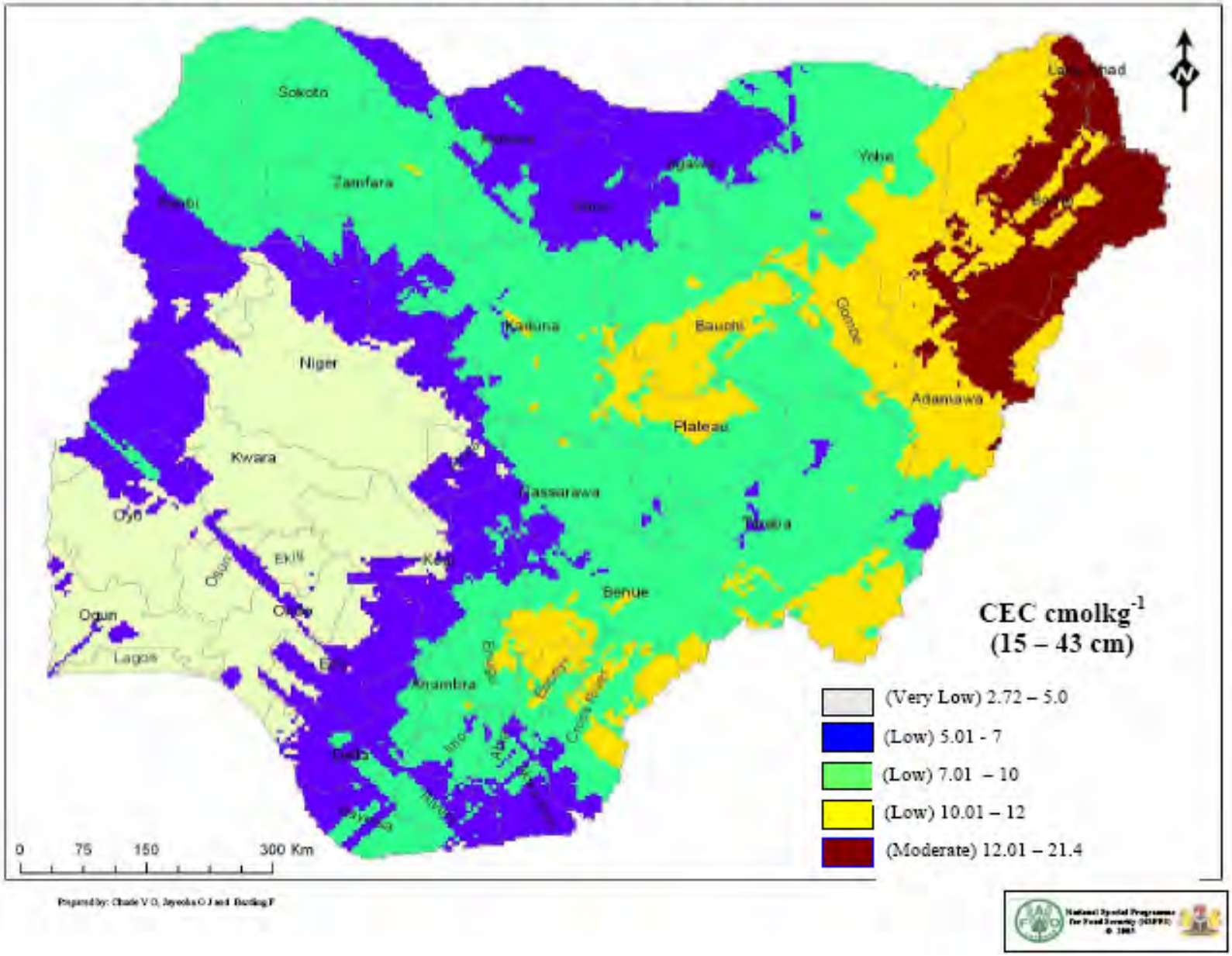


Prepared by: Chude V O, Jayeoba O J and Bending F

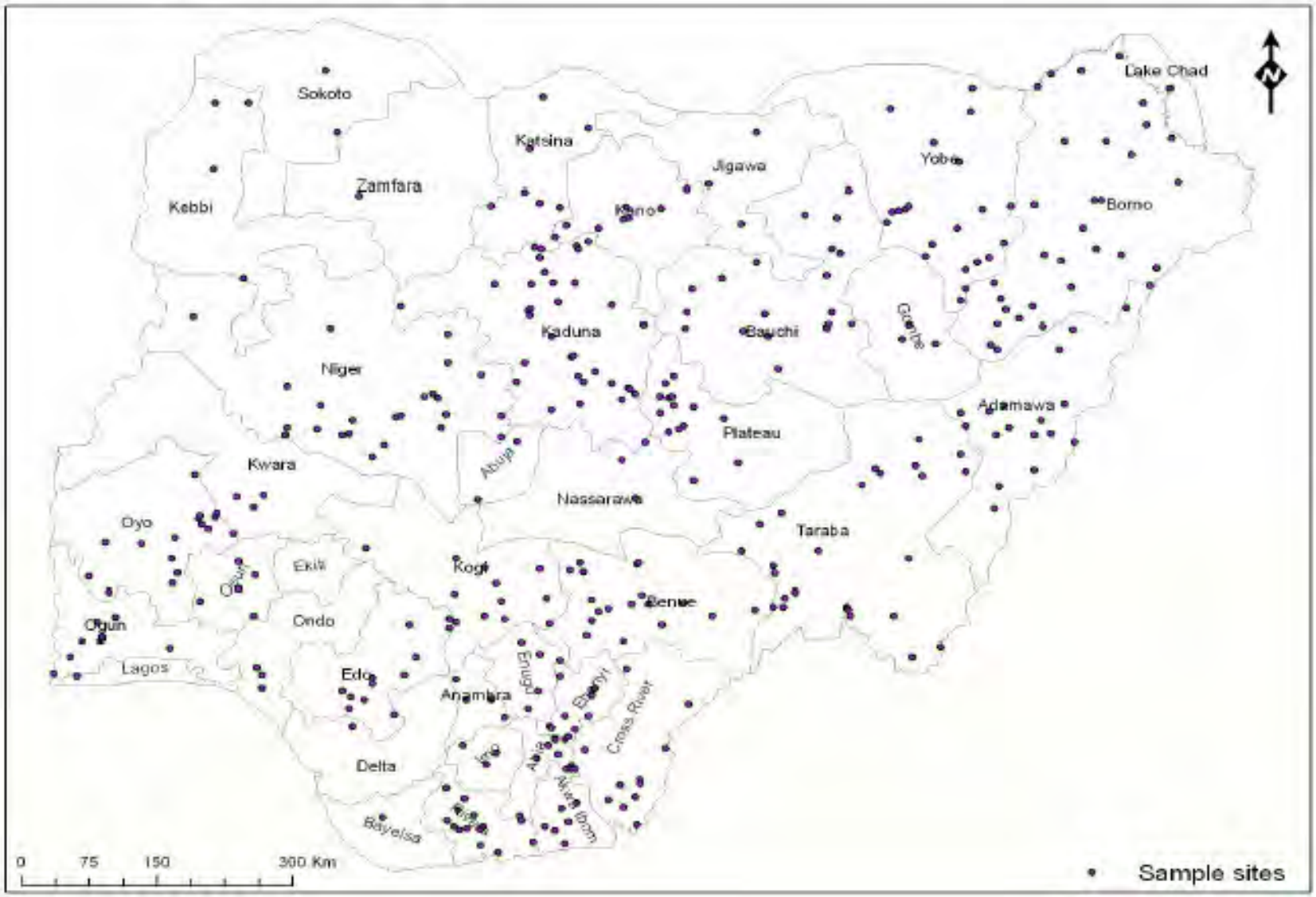
Map of Nigeria Showing different acidity classes for the subsoil.



Map of Nigeria Showing different CEC fertility classes for the subsoil.



Map of Nigeria Showing sample sites.



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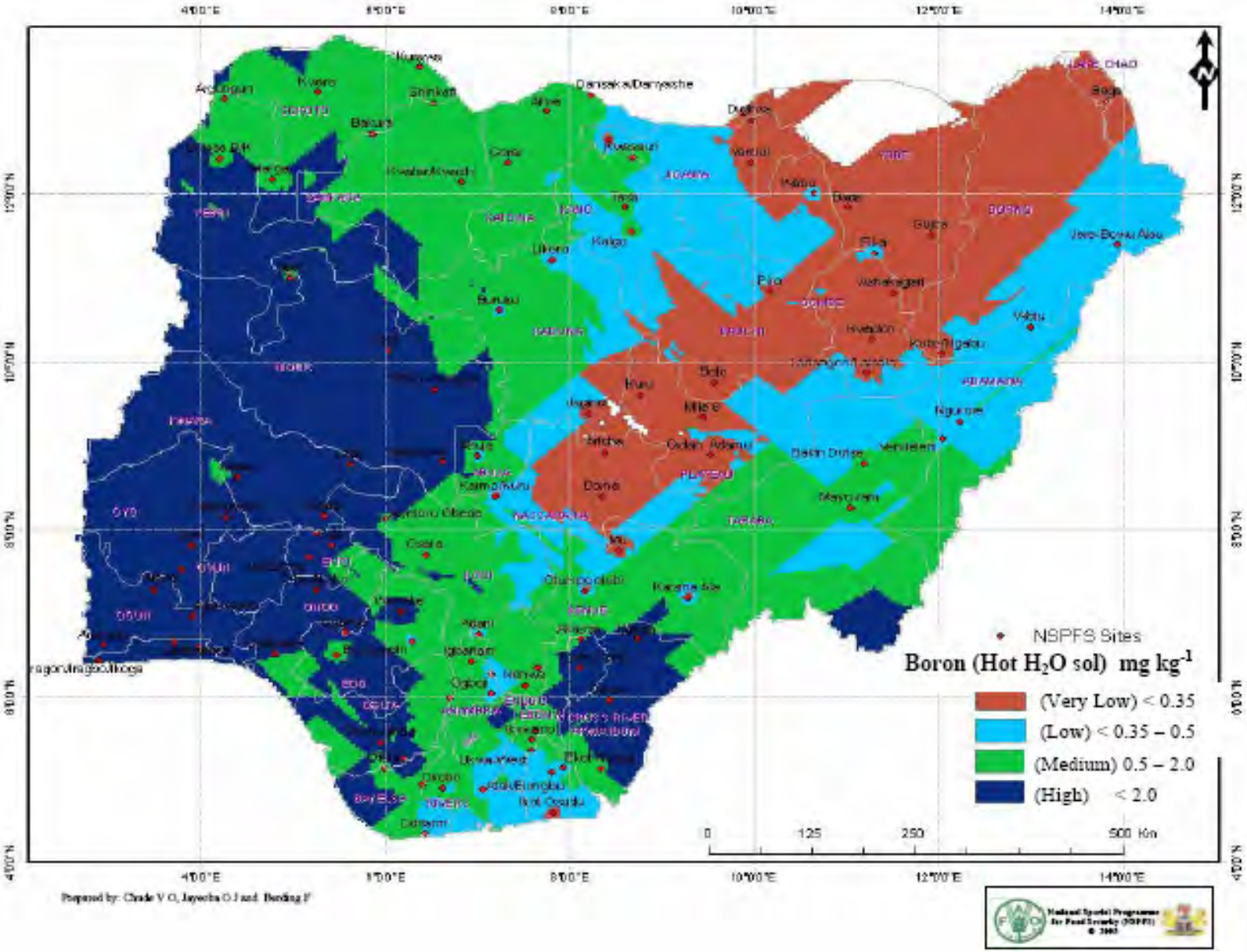

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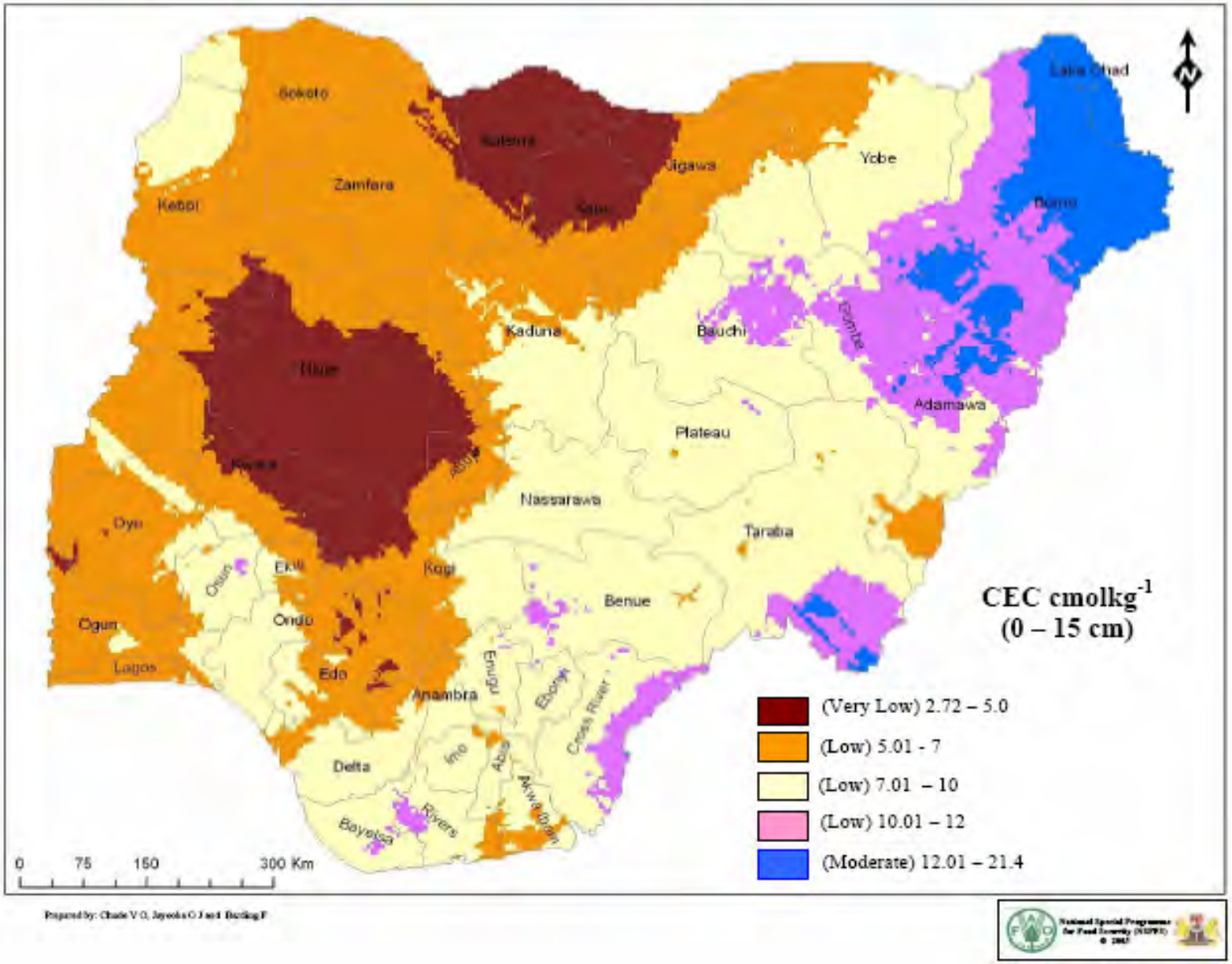

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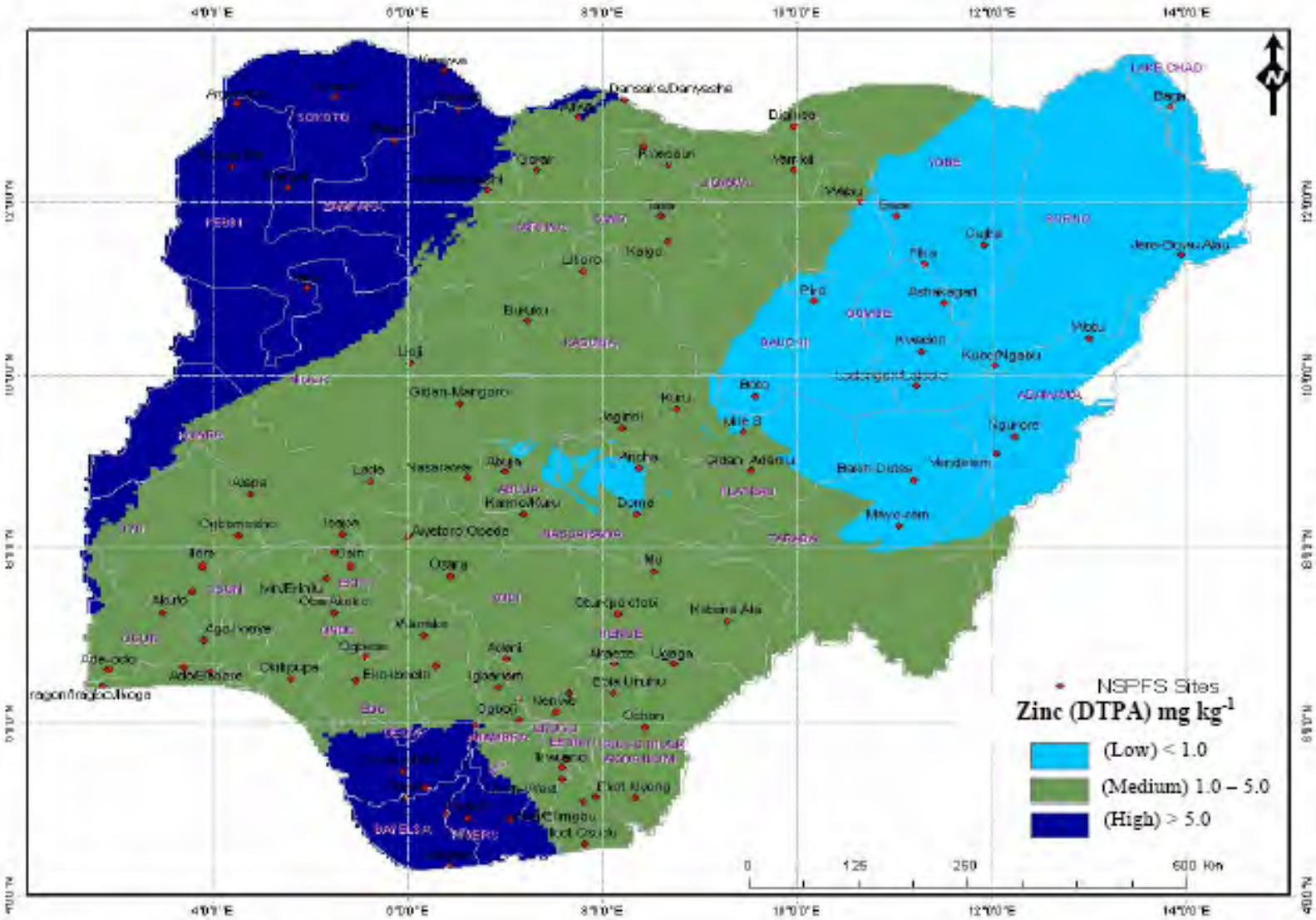
Map of Nigeria Showing different Zinc fertility classes.



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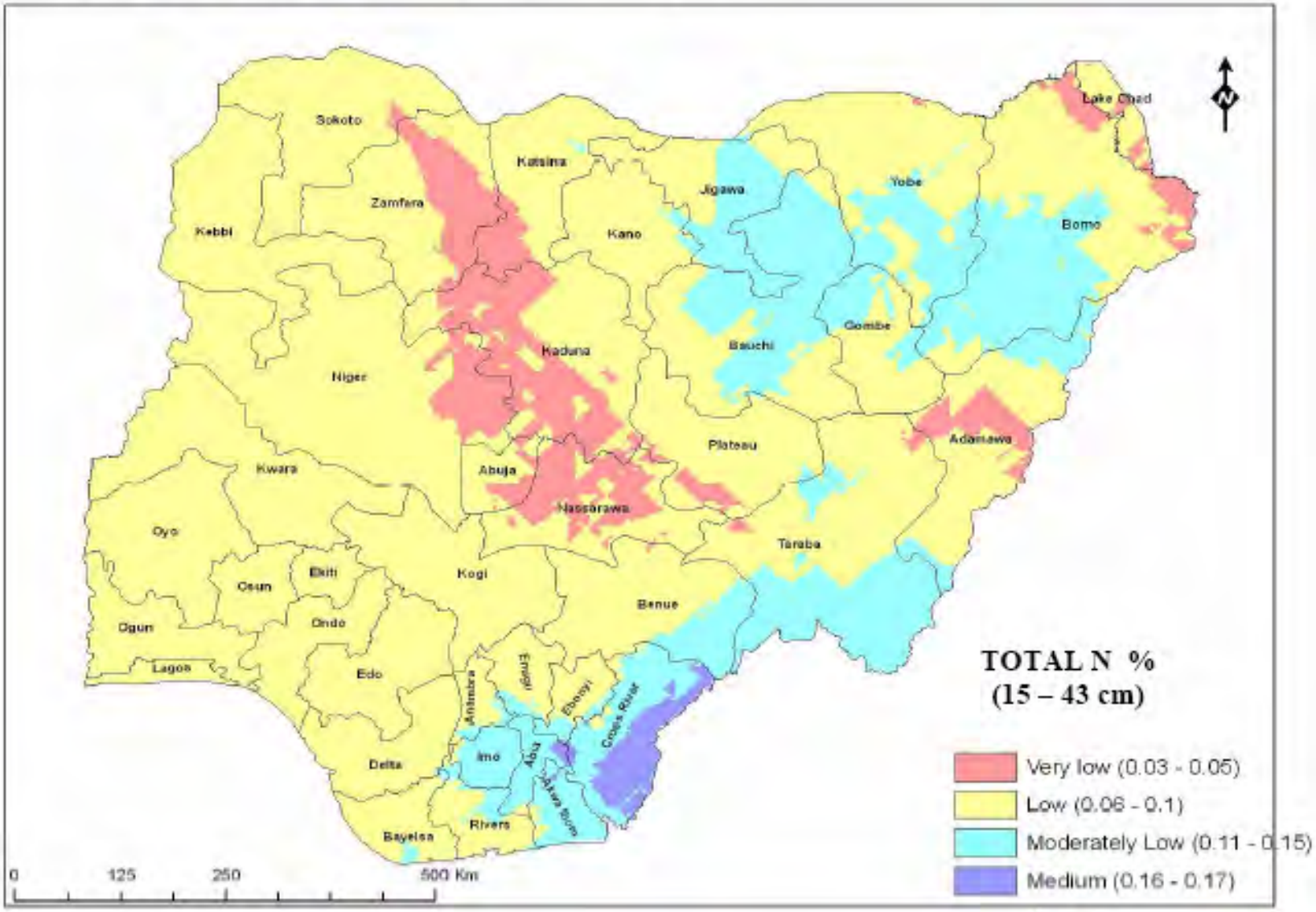
Map of Nigeria Showing different Total N fertility classes for the subsoil.



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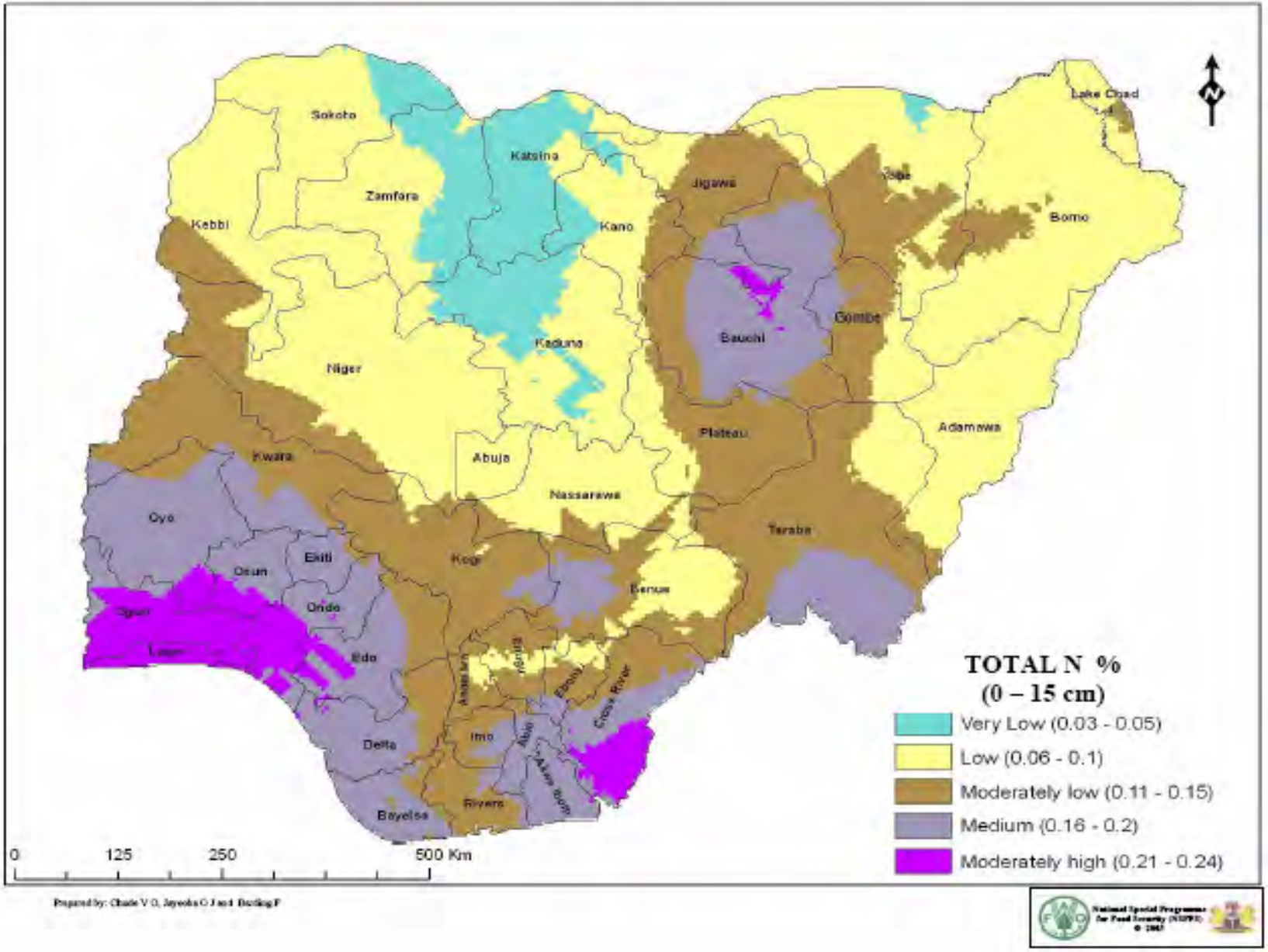
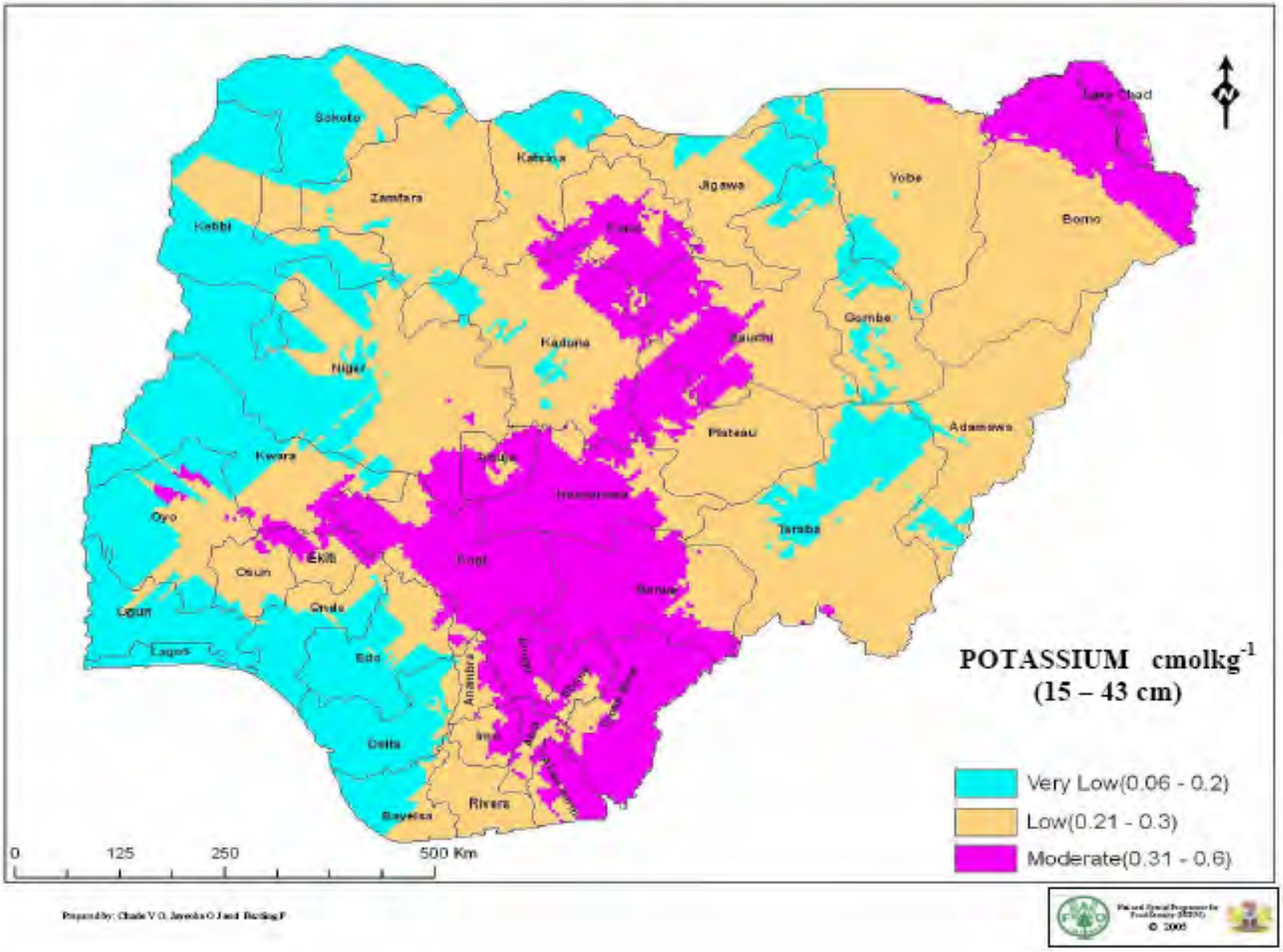


Map of Nigeria Showing different Potassium fertility classes for the subsoil.



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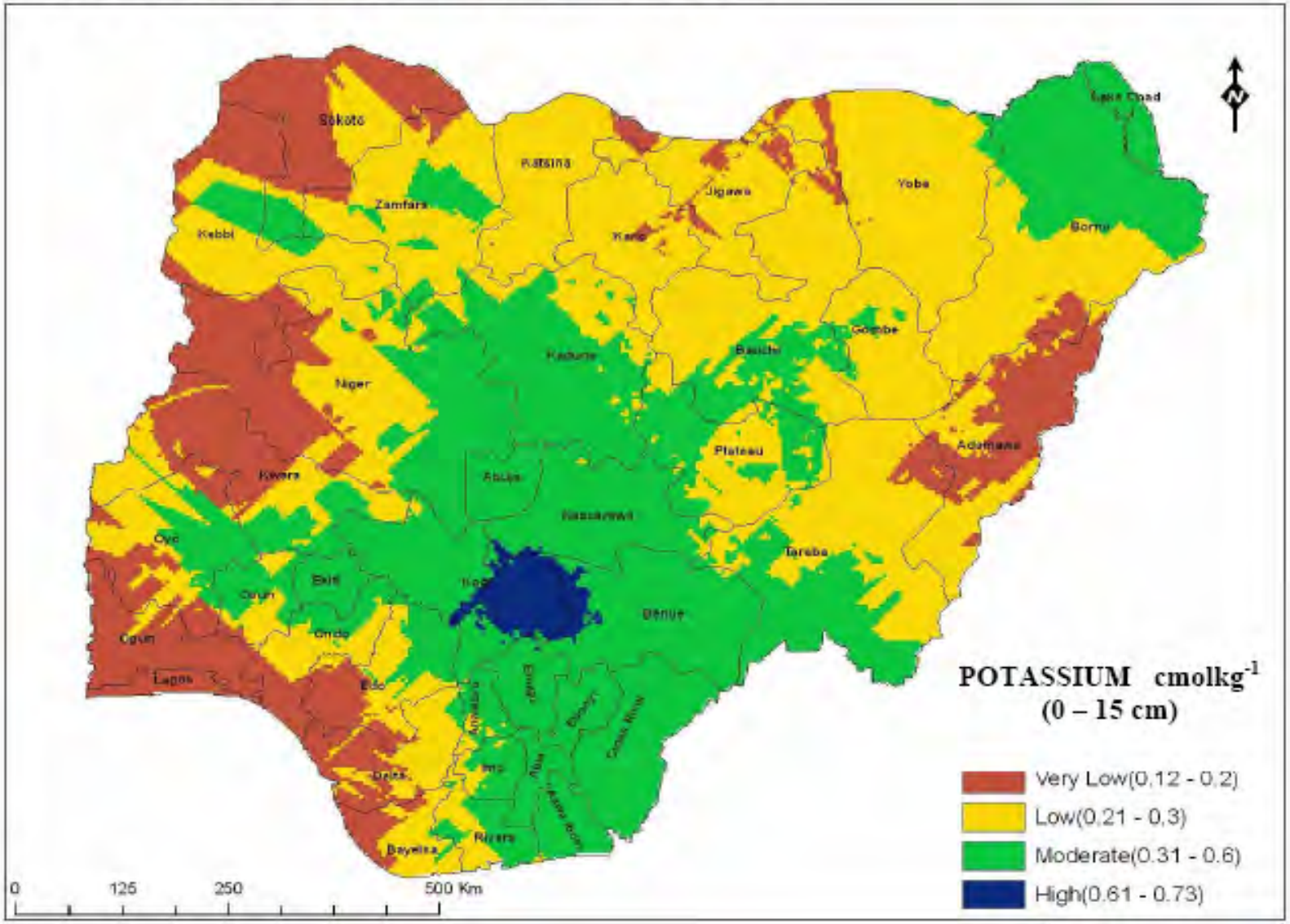

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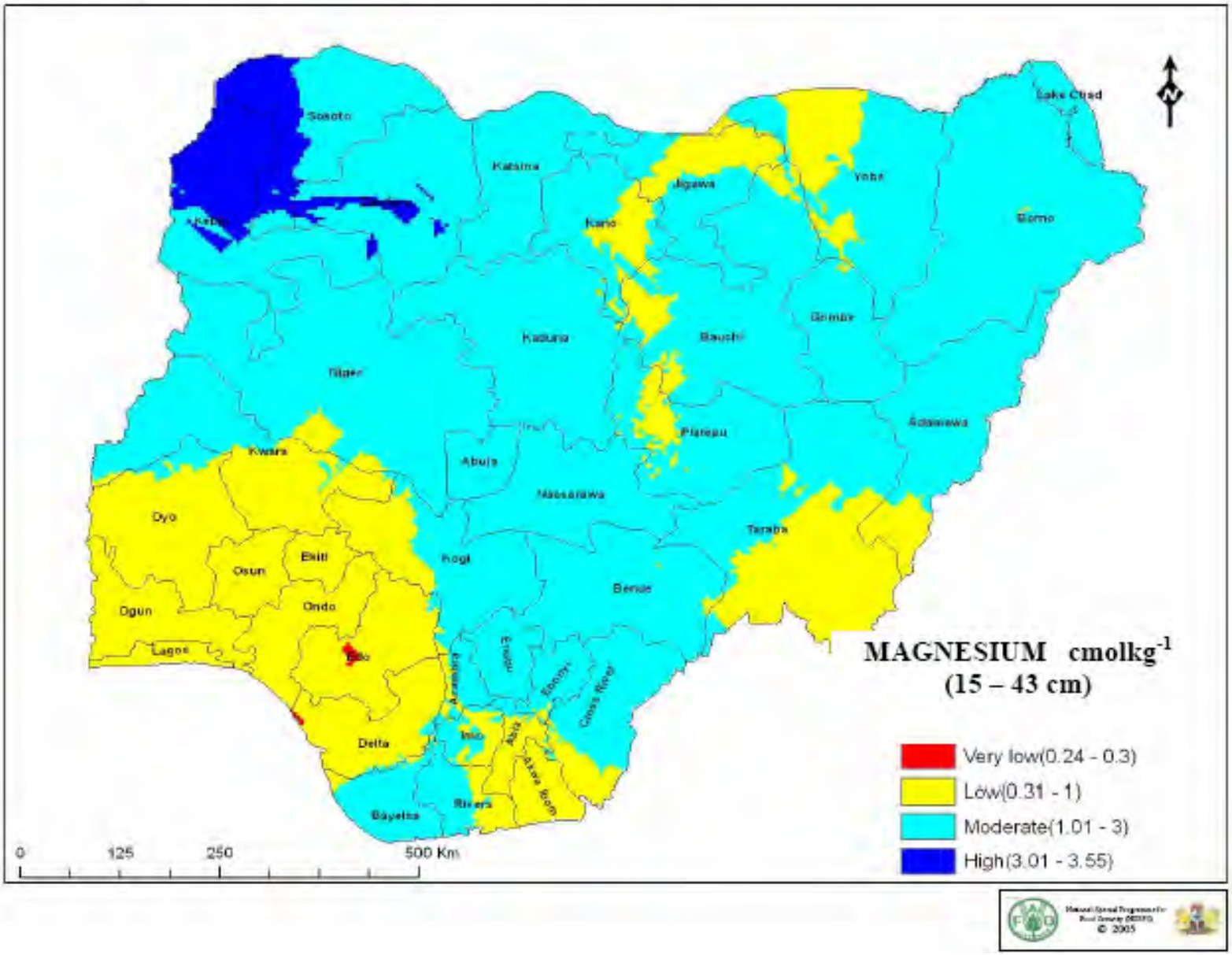
Map of Nigeria Showing different Magnesium fertility classes for the subsoil.



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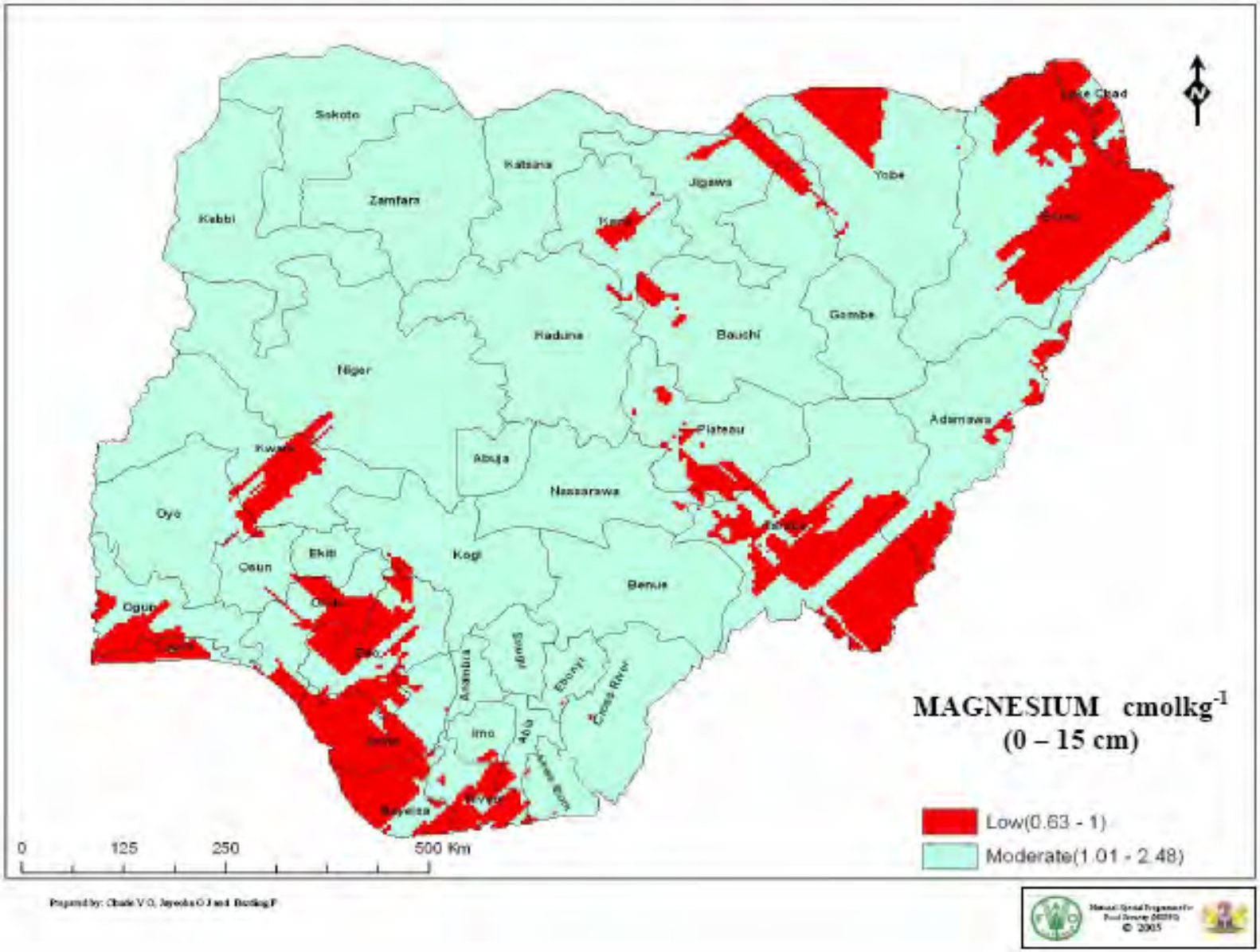
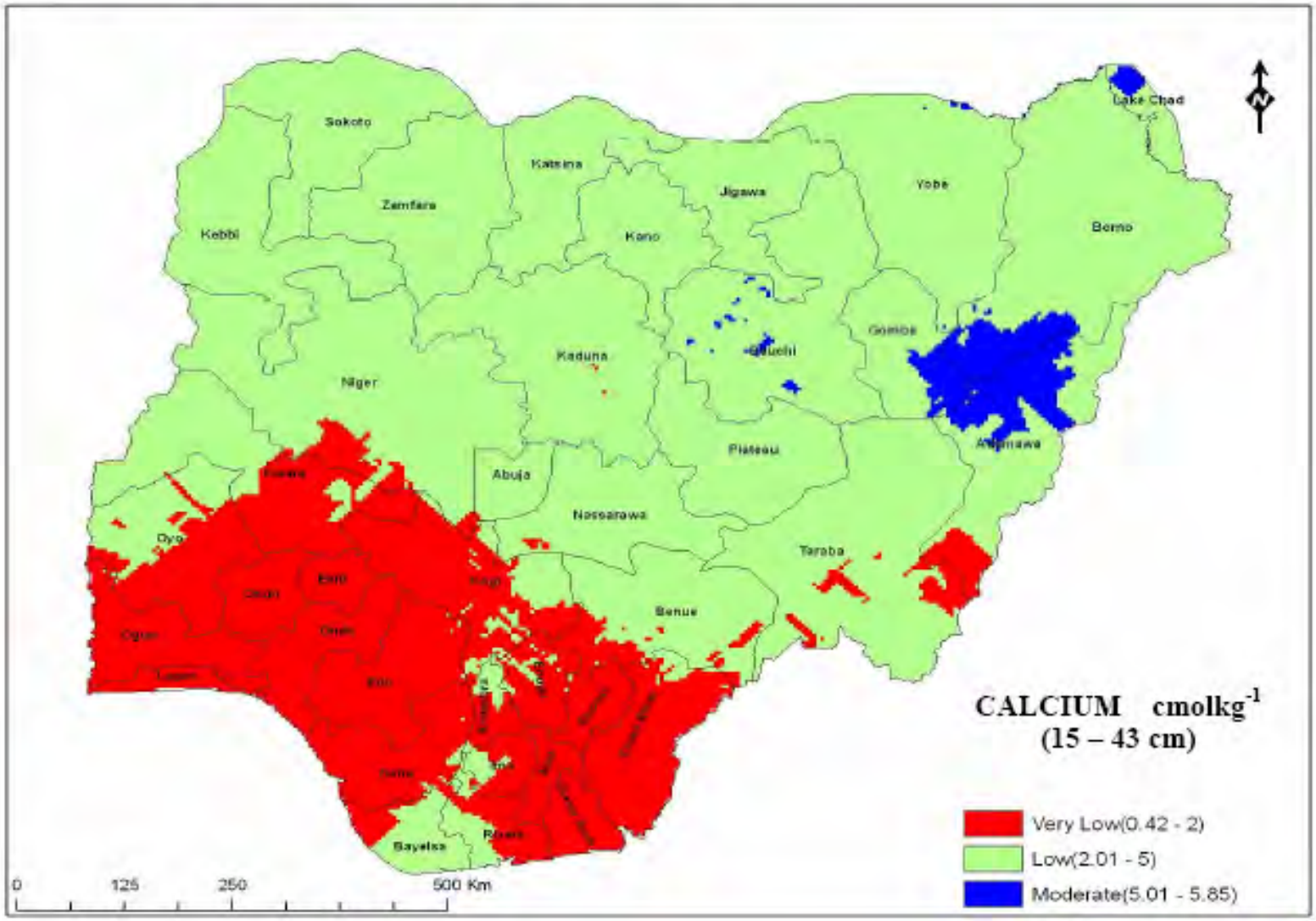
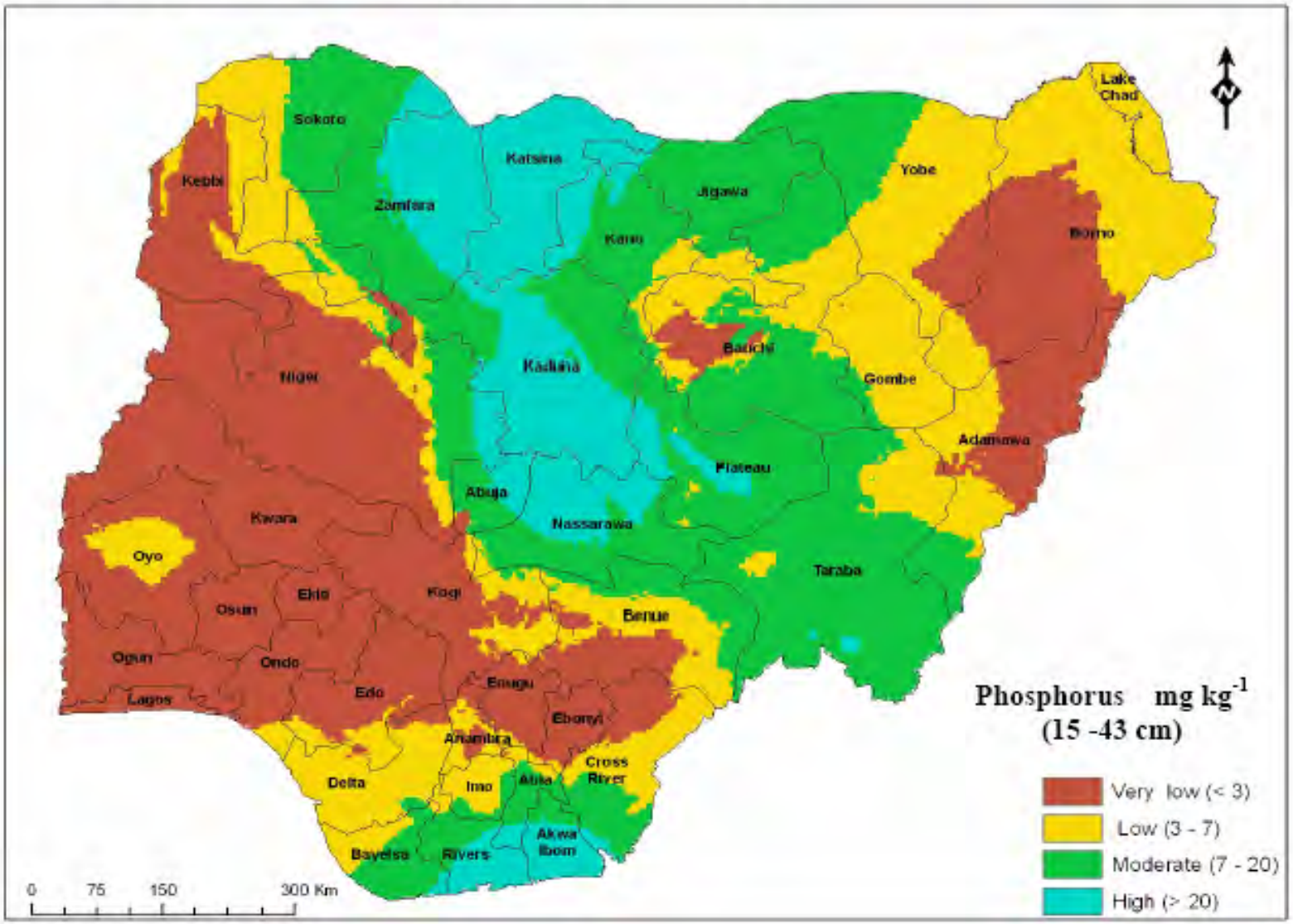


Map of Nigeria Showing different Calcium fertility classes for the subsoil.



Map of Nigeria Showing different Calcium fertility classes for the topsoil.

Map of Nigeria Showing different Phosphorus fertility classes for the subsoil.



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