



ANNEXURES

ANNEXURE I

FAO's Voluntary Guidelines for Sustainable Soil Management (VGSSM)

These guidelines are of prime importance and relevance for sustainable use of land resources to sustain crop productivity particularly in areas of poor soil, water resources and were developed within the frame-work of the Global Soil Partnership (GSP). The aim is to provide general technical and policy recommendations on sustainable soil management (SSM) for a wide range of stakeholders. The guidelines were adopted by the 4th GSP Plenary Assembly (Rome, 25 May 2016), approved by the 25th session of the FAO Committee on Agriculture (Rome, 28 September 2016) and finally endorsed by the 155th session of the FAO Council (Rome, 5 December 2016). VGSSM emphasize conservation of soil resources against degradation such as soil salinization, soil alkalization, soil contamination, soil acidification, soil compaction, soil erosion, and soil biodiversity losses. These are generally accepted, practically proven and scientific based principles to promote SSM and provide guidance to all stakeholders on how to translate these principles into practice, be it for farming, pastoralism, forestry or more general natural resources management. These guidelines are of voluntary nature with no legal binding and not expected to provide detailed recommendations and are designed for specific decisions making at all relevant levels. These elaborated principles outlined in the revised World Soil Charter take into account the evidence provided in the Status of the World's Soil Resources (SWSR). They contribute to global, regional and national efforts towards the eradication of hunger and poverty due to the importance of soils in sustainable development. Customization of these VGSSM based on country specific constraints hampering sustainable crop productivity and implementation at national level are up to the provincial and national institutions. The potential target audience of the VGSSM includes: government officials, policy makers, farmers, pastoralists, forest and land managers, extension services and agricultural advisors, development partners, civil society, private sector, and academia.



Food and Agriculture Organization
of the United Nations

Voluntary Guidelines for Sustainable Soil Management



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INTERGOVERNMENTAL
TECHNICAL PANEL ON SOILS



Voluntary Guidelines for Sustainable Soil Management



The present VGSSM is the result of an inclusive and participatory process that involved multiple stakeholders - including academic, national and research institutions, international organizations, NGOs, civil society and the private sector – who contributed with scientific knowledge and experience on how soils should be sustainably managed for properly delivering ecosystem services while halting degradation.

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Foreword

Humankind is facing tremendous challenges in agriculture: the climate is changing, the global population is growing quickly, cities are expanding, diets are undergoing major shifts – and soils are becoming increasingly degraded. In this fast-changing world, and given the urgent need to eliminate hunger and ensure food security and nutrition, understanding and attaining sustainable soil management has never been more important.

Indeed, the Sustainable Development Goals identify the need to restore degraded soils and improve soil health. There is widespread agreement that we must nurture and unlock the full potential of soils, so as to be able to not only support food production but also to store and supply more clean water, maintain biodiversity, sequester carbon and increase resilience in a changing climate. This is a goal that requires the universal implementation of sustainable soil management.

Soils are the foundation of food production and many essential ecosystem services. It has been shown that sustainable soil management contributes to increasing food production, enhancing the nutrient content of food, and adapting to and mitigating climate change.

The conservation and responsible management of soils is thus central to FAO's mandate to help eliminate hunger, food insecurity and malnutrition. To ensure greater recognition of the essential contributions of soils to agriculture and food production, as well as their crucial ecosystem services, the FAO Council established the Global Soil Partnership (GSP) in December 2012, as a coalition of willing partners to promote and implement sustainable soil management at all scales, from local to global. Since then, the GSP has been conducting a vigorous campaign to promote sustainable soil management.

Under the aegis of the GSP, the World Soil Charter, which contains key principles and guidance for action towards sustainable soil management, was revised in 2015, in light of major policy and scientific developments over the past three decades. In turn, these *Voluntary Guidelines for Sustainable Soil Management*, endorsed by the FAO Council in December 2016 at its 155th Session, complement the World Soil Charter by further elaborating principles and practices for incorporation into policies and decision-making.

I expect this timely tool to both guide practitioners and help generate the necessary support to dramatically increase the area under sustainable soil management worldwide. I commend the collaborative and inclusive efforts that enabled the development of these *Voluntary Guidelines*. FAO strongly encourages their uptake, and is ready to continue supporting Members in implementing effective policies and actions towards healthy soils.



JOSE GRAZIANO DA SILVA
FAO Director-General



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1. Introduction

These Voluntary Guidelines for Sustainable Soil Management (VGSSM) were developed through an inclusive process within the framework of the Global Soil Partnership (GSP). They aim to be a reference providing general technical and policy recommendations on sustainable soil management (SSM) for a wide range of committed stakeholders. The guidelines were adopted by the 4th GSP Plenary Assembly (Rome, 25 May 2016), approved by the 25th session of the FAO Committee on Agriculture (Rome, 28 September 2016) and finally endorsed by the 155th session of the FAO Council (Rome, 5 December 2016).

1.1 Background and rationale

Soils are an essential and non-renewable natural resource hosting goods and services vital to ecosystems and human life. Soils are fundamental for producing crops, feed, fibre, fuel, and they filter and clean tens of thousands of cubic kilometers of water each year. As a major storehouse for carbon, soils also help regulate emissions of carbon dioxide and other greenhouse gases, which is fundamental for regulating climate. SSM is an integral part of sustainable land management, as well as a basis for addressing poverty eradication, agricultural and rural development, promoting food security and improving nutrition.

Soil is the world's largest terrestrial pool of carbon^{1,2} and approximately 95% of global food is produced in soil³. SSM is a valuable tool for climate change adaptation and a pathway for safeguarding key ecosystem services and biodiversity. Due to the incalculable value soils provide to society through ecosystem services, SSM ensures a high return on investment by supporting and increasing these services. Widespread adoption of SSM practices generates multiple socio-economic benefits, especially for smallholder farmers and large scale agricultural producers worldwide whose livelihoods directly depend on their soil resources.

However, evidence recently provided in the Status of the World's Soil Resources (SWSR) report and other studies shows that about 33% of global soils are moderately or highly degraded^{4,5}, *i.e.* due to unsustainable management practices. On a global scale an annual loss of 75 billion tons of soil from arable land is estimated to cost about USD 400 billion each year in lost agricultural production⁶. This loss also significantly reduces the soil's ability to store and cycle carbon, nutrients, and water. Annual cereal production losses due to erosion have been estimated at 7.6 million tonnes.

Growing concerns about the state of global soils resulted, amongst others, in the establishment of the Global Soil Partnership, the proclamation of the International Year of Soils (2015) by the UN General Assembly and the adoption of the revised World Soil Charter by the FAO Conference. In a broader context, the 2030 Agenda for Sustainable Development adopted a number of related targets in 2015, *i.a.* those aimed at restoring degraded soil, striving to achieve a land degradation-neutral world and implementing resilient agricultural practices that progressively improve soil quality and minimize soil contamination.

1 Carbon sequestration in dryland soils. FAO, 2004

2 Land use, land use change, and forestry. Summary for policy-makers. IPCC, 2000 (pp. 3-4)

3 Healthy soils are the basis for healthy food production, FAO, 2015.

4 Status of the World's Soil Resources (SWSR). Main Report. FAO and ITPS, Rome, 2015 (p. xix)

5 The state of the world's land and water resources for food and agriculture (SOLAW). Managing systems at risk. FAO, Rome and Earthscan, London, 2011 (p. 113).

6 The value of land: Prosperous lands and positive rewards through sustainable land management. The Economics of Land Degradation (ELD) Initiative, 2015 (p. 80).

SSM strongly contributes to collective efforts towards climate change adaptation and mitigation, combating desertification and promoting biodiversity, and therefore has specific relevance to the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD) and United Nations Convention on Biological Diversity (UNCBD).

The revised World Soil Charter calls for the incorporation of SSM principles and practices into policy guidance. In response, the GSP decided to develop the present Voluntary Guidelines in line with its overall goal of promoting SSM.

1.2 Objectives

The objectives of the VGSSM are: to present generally accepted, practically proven and scientifically based principles to promote SSM and to provide guidance to all stakeholders on how to translate these principles into practice, be it for farming, pastoralism, forestry or more general natural resources management.

1.3 Nature and scope

The VGSSM are of voluntary nature and are not legally binding. They elaborate the principles outlined in the revised World Soil Charter, taking into account the evidence provided in the SWSR. The guidelines address technical aspects of SSM including core characteristics of sustainably managed soils, key challenges and potential solutions to address them. The VGSSM focus mostly on agriculture which is broadly defined as the production of food, fibre, feed, timber and fuel, although many of the principles described have a significant influence on ecosystem services provided by managed and unmanaged soil systems.

The guidelines are not expected to provide detailed recommendations, but are designed to inform strategic and context-specific decision-making at all relevant levels. They are intended to contribute to global, regional and national efforts towards the eradication of hunger and poverty due to the importance of soils in sustainable development.

1.4 Target audience

By providing an easily accessible and readily understandable reference to a wide range of stakeholders, the potential target audience of the VGSSM includes: government officials, policy makers, farmers, pastoralists, forest and land managers, extension services and agricultural advisors, development partners, civil society, private sector and, academia, etc.

1.5 Definition of sustainable soil management

In these guidelines, SSM is defined according to Principle 3 in the revised World Soil Charter as follows:

“Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. The balance between the supporting and provisioning services for plant production and the regulating services the soil provides for water quality and availability and for atmospheric greenhouse gas composition is a particular concern”.

The types of ecosystem services and the soil functions referred to in the definition can be elaborated as follows:

- Supporting services include primary production, nutrient cycling and soil formation;
- Provisioning services comprise the supply of food, fibre, fuel, timber and water; raw earth material; surface stability; habitat and genetic resources;
- Regulating services imply the regulation of aspects such as water supply and quality, carbon sequestration, climate regulation, control of floods and erosion; and
- Cultural services denote the aesthetic and cultural benefits derived from soil use.

SSM is associated with the following characteristics:

1. Minimal rates of soil erosion by water and wind;
2. The soil structure is not degraded (e.g. soil compaction) and provides a stable physical context for movement of air, water, and heat, as well as root growth;
3. Sufficient surface cover (e.g. from growing plants, plant residues, etc.) is present to protect the soil;
4. The store of soil organic matter is stable or increasing and ideally close to the optimal level for the local environment;
5. Availability and flows of nutrients are appropriate to maintain or improve soil fertility and productivity, and to reduce their losses to the environment;
6. Soil salinization, sodification and alkalization are minimal;
7. Water (e.g. from precipitation and supplementary water sources such as irrigation) is efficiently infiltrated and stored to meet the requirements of plants and ensure the drainage of any excess;
8. Contaminants are below toxic levels, i.e. those which would cause harm to plants, animals, humans and the environment;
9. Soil biodiversity provides a full range of biological functions;
10. The soil management systems for producing food, feed, fuel, timber, and fibre rely on optimized and safe use of inputs; and
11. Soil sealing is minimized through responsible land use planning.



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2. Challenges for achieving sustainable soil management

Soils have diverse chemical, physical and biological properties. As a consequence, they differ in their responses to management practices, their inherent ability to deliver ecosystem services, as well as their resilience to disturbance and vulnerability to degradation. The Status of the World's Soil Resources report identified ten key threats that hamper the achievement of SSM. These threats are: soil erosion by water and wind, soil organic carbon loss, soil nutrient imbalance, soil salinization, soil contamination, acidification, loss of soil biodiversity, soil sealing, soil compaction and waterlogging. These different threats vary in terms of intensity and trend depending on geographical contexts, though they all need to be addressed in order to achieve sustainable soil management.

SSM shall contribute to addressing global challenges, and meeting international commitments, including:

- the 2030 Agenda for Sustainable Development, where SSM could directly or indirectly contribute to achieving several of the agreed goals and targets;
- the Zero Hunger Challenge (to end hunger and malnutrition and assure food security for a growing population);
- climate change adaptation and mitigation, especially in the light of the Paris Agreement adopted at the UNFCCC COP21, which embodies a strong commitment to address climate change and give agriculture a prominent role in that process;
- the commitment to combat desertification and mitigate effects of drought, especially the strive to achieve a land degradation neutral world, taking note of the potential benefits for all as per the last UNCCD COP12;
- the Aichi targets which underline an important agenda to preserve biodiversity and the provision of ecosystem services;
- securing land tenure under the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT).

This context points to major opportunities to promote SSM. Taking the above into account, an enabling environment for promoting SSM is fostered by the following core actions:

- Establishing or strengthening inclusive SSM-supportive agricultural/environmental policies

Where appropriate, inclusive policies to promote SSM should be linked to agricultural and environmental policies, so that their implementation provides multiple benefits. If existing, these policies can be reviewed, as appropriate, to mainstream SSM.

- Increasing responsible investment and positive incentives aimed at promoting sustainable soil management

Where appropriate, responsible investment in SSM according to the Principles for Responsible Investments in Agriculture and Food Systems (CFS-RAI) should be increased. Provision of positive incentives to those stakeholders who implement SSM principles while recognizing the value of ecosystem services could be envisaged.

- Promoting secure land tenure rights according to the VGGT

SSM is affected by secure land tenure rights being in place or not. Access and tenure rights are an important factor for SSM to be properly implemented by land users and to enable long-term planning.

- Fostering and strengthening targeted soil research

It is imperative that investment in soil research is increased to enable national research programs and their partners to work with land users to identify and address the constraints they face in increasing the ecosystem services provided by soils (i.e. soil productivity).

- Preventing or minimizing soil degradation and restoring/rehabilitating degraded soils (including historically degraded soils)

Soil degradation shall be minimized using SSM, especially through soil conservation approaches that proved to be successful. Soil rehabilitation and/or soil restoration should also be a priority, returning degraded soils to productivity, especially in historically sound agriculture or other production systems currently under threat.

- Promoting effective education programmes

Where appropriate, education on soils (formal or informal) should be strengthened. That could start with the reflection of their importance in the school's curricula and extending to more professional levels. Capacity development on SSM should be enhanced so that more professionals are brought up-to-date on "state of the art" methods and tools.

- Ensuring adequate inclusion of SSM in extension services

Agricultural extension services should promote SSM principles and practices.

- Establishing/strengthening soil information systems

Considering the living nature of soils, the assessment of their status should be a pre-condition to planning any SSM intervention. Soil data and information (including local knowledge) are essential for understanding soil conditions and trends in soil functions, as well as for targeting interventions to increase productivity. Where appropriate, national soil information systems should be established or strengthened in order to have solid monitoring capacities of soil condition in place. These systems would also contribute to the Global Soil Information System being promoted by the Global Soil Partnership.

- Fostering international cooperation/collaboration on soils

International cooperation on soils should foster the exchange of knowledge, technology and information. Various arrangements including "North-South", "South-South" and "Triangular" cooperation could be used for that purpose.

- Promoting communication on SSM practices

Pursuing the efforts of the International Year of Soils 2015, SSM practices should be promoted and disseminated in view of their provisioning of important ecosystem services.

3. Guidelines for sustainable soil management

The following constitutes technical guidelines to address soil threats that hamper SSM. They should not be viewed as a full list of good practices, but rather a technical reference to be applied on a context specific basis. Specific technical manuals may be developed later to provide complementary tools.

3.1 Minimize soil erosion

The SWSR report identified soil erosion by water and wind as the most significant threat to global soils and the ecosystem services they provide. Soil erosion causes the loss of surface soil layers containing organic and mineral nutrient pools, partial or complete loss of soil horizons and possible exposure of growth-limiting subsoil, as well as off-site impacts such as damage to private and public infrastructure, reduced water quality and sedimentation. Soil erosion is accelerated by human activities through, amongst others, reduced plant or residue cover, tillage and other field operations, and reduced soil stability leading to soil creep and landslides.

- Land-use changes such as deforestation or improper grassland-to-cropland conversion that cause removal of surface cover and loss of soil carbon should be avoided or carefully planned and appropriately implemented if unavoidable;
- A cover of growing plants or other organic and non-organic residues that protects the soil surface from erosion should be maintained through implementation of appropriate measures such as mulching, minimum tillage, no-till by direct seeding with attention to reduced herbicide use, cover crops, agro-ecological approaches, controlled vehicle traffic, continuous plant cover and crop rotation, strip cropping, agroforestry, shelter belts, and appropriate stocking rates and grazing intensities;
- Erosion by water on sloping and relatively steep lands should be minimized by measures that reduce runoff rates and velocity such as strip cropping, contour planting, crop rotation, intercropping, agroforestry, cross slope barriers (e.g. grass strips, contour bunds and stone lines), terrace construction and maintenance, and grassed waterways or vegetated buffer strips;
- Where appropriate, riparian buffers, buffer strips, wetlands, water harvesting and cover crops should be used/installed to minimize export of soil particles and associated nutrients and contaminants from the soil system and protect the downstream areas from damaging impacts; and Erosion by wind, including dust storms, should be minimized and mitigated through vegetative (trees and shrubs) or artificial (stone walls) wind breaks to reduce wind velocity.

3.2 Enhance soil organic matter content

Soil organic matter (SOM) plays a central role in maintaining soil functions and preventing soil degradation. Soils constitute the largest organic carbon pool on the Earth and play a critical role in regulating climate and mitigating climate change through trade-offs between greenhouse gas emission and carbon sequestration. For this reason, SOM is strategic for climate change adaptation and mitigation, and global stores of SOM should be stabilized or increased. A loss of soil organic carbon (SOC) due to inappropriate land use or the use of poor soil management or cropping practices can cause a decline in soil quality and soil structure, and increase soil erosion, potentially leading to emissions of carbon into the atmosphere. On the other hand, appropriate land use and soil management can lead to increased SOC and improved soil quality that can partially mitigate the rise of atmospheric CO₂.

- Increase biomass production by increasing water availability for plants using methods (e.g., irrigation with drippers or microsprinklers; irrigation scheduling; monitoring of soil moisture or loss of water via evapotranspiration) that maximize water-use efficiency and minimize soil erosion and nutrient leaching, using cover crops, balancing fertilizer applications and effective use of organic amendments, improving vegetative stands, promoting agroforestry and alley cropping, and implementing reforestation and afforestation;
- Protect organic carbon-rich soils in peatlands, forests, pasturelands, etc.;
- Increase organic matter content through practices such as: managing crop residues, using forage by grazing rather than harvesting, practicing organic farming, applying integrated soil fertility management and integrated pest management, applying animal manure or other carbon-rich wastes, using compost, and applying mulches or providing the soil with a permanent cover;
- Fire should preferably be avoided, except where fire is integral to land management, in which case the timing and intensity of burning should aim to limit losses of soil functions. Where fire is a naturally occurring event, steps to minimize erosion and encourage re-vegetation after fire should be considered, where practical.
- Make optimum use of all sources of organic inputs, such as animal manure and properly processed human wastes;
- Management practices such as cover crops, improved fallow plant species, reduced- or no-tillage practices, or live fences should be adopted to ensure the soil has a sufficient organic cover;
- Decrease decomposition rates of soil organic matter by practicing minimum or no-tillage without increasing the use of herbicides; and
- Implementing crop rotations, planting legumes (including pulses) or improving the crop mix.

3.3 Foster soil nutrient balance and cycles

The concepts of sufficiency and utilization efficiency apply especially to nutrient dynamics in the soil-water-nutrients-plant root continuum. Plant nutrition should be based on crop needs, local soil characteristics and conditions, and weather patterns. Plant nutrition can be enhanced through nutrient recycling or additions including mineral (chemical) fertilizers, organic fertilizers and other soil amendments including primary sources (e.g. rock phosphate) and secondary sources (e.g. phosphorus from sewage sludge). It is crucial to select an appropriate plant nutrient management system and approach alongside assessing the suitability of the land for a given land use.

The benefits of sufficient and balanced nutrient supply for plant needs are well-established and include: production of food, feed, fibre, timber, and fuel at levels at, or close to, the optimum potential in the specific geographical context; reduced need for pest control measures, external application of organic and inorganic amendments, and mineral fertilizers; less pollution resulting from inappropriate use of agro-chemicals; and enhanced soil carbon sequestration through biomass production and restitution to the soil.

The lack of basic nutrients leads to the underdevelopment of plants and decrease in yields and crop nutritional value. The consequences of excess nutrients in soils are a) the loss of excess nutrients (especially nitrogen and phosphorus) from agricultural fields, causing eutrophication and deterioration of water quality and terrestrial and aquatic ecosystems; b) increased release of the greenhouse gas nitrous oxide from soils to the atmosphere; c) leaching of mobile forms of nitrogen to water used for human consumption, with potential human health impacts; and d) crop failure.

- Natural soil fertility and natural nutrient cycles should be improved and maintained through the preservation or enhancement of soil organic matter. Improved soil fertility can be attained through soil conservation practices such as the use of crop rotations with legumes, green- and animal manures, and cover crops in combination with reduced- or no-tillage with attention to reduced herbicide use, as well as agroforestry. Nutrient cycles are best managed in integrated systems such as crop-livestock systems or crop-livestock-forest systems;
- Nutrient use efficiency should be optimized by adopting measures such as applying balanced and context adapted soil organic and inorganic amendments (e.g. compost and liming agents, respectively) and/or innovative products (e.g. slow and controlled release fertilizers), as well as the recycling and reuse of nutrients;
- Fertilizer application methods, types, rates and timing should be appropriate to limit losses and promote balanced crop nutrient uptake. This should be based on soil and plant analyses and be a long-term endeavor rather than short term action;
- The addition of soil micronutrients should be considered when planning soil fertilization;
- Practical sources of plant nutrients should be used, including the precise and judicious use of organic and mineral amendments, inorganic fertilizers, and agricultural bio-products. These amendments and bio-products include liquid, semi-solid or solid manures, crop residues, composts, green manures, household refuse, clean ash generated during bioenergy production, soil amendments and inoculants. In order to increase their efficiency, such measures should be combined with the mitigation of other limiting factors (such as water deficiency). Safe use (including tolerable levels of contaminants and pollutants, and worker health) of the amendments should be ensured;
- Soil and plant-tissue testing and field assessments should be adopted and used. This provides valuable guidance in diagnosing and correcting limiting factors in crop production related to plant nutrients, salinity, sodicity, and extreme pH conditions. Such guidance is key for making informed decisions and monitor progress;
- Where appropriate, livestock movement and grazing should be managed to optimize manure and urine deposition;
- Application of liming agents in acid soils is a prerequisite for optimal nutrient use efficiency in such soils, while application of organic amendments such as compost, as well as appropriate soil-crop management should be considered for alkaline and other soils; and
- Naturally occurring mineral fertilizer resources like rock phosphate or potash should be allocated efficiently and strategically to ensure the continued availability of adequate amounts of mineral inputs for future generations.

3.4 Prevent, minimize and mitigate soil salinization and alkalization

Salinization is the accumulation of water-soluble salts of sodium, magnesium and calcium in the soil. It is the consequence of high evapotranspiration rates, inland sea water intrusion, and human-induced (e.g. improper irrigation) processes. Salinization reduces crop yields and, above certain thresholds, completely eliminates crop production.

- Surface cover should be optimized to reduce evaporation losses;
- Efficiency of irrigation water use should be increased through improved conveyance, distribution, and field application methods. Application methods should be used that operate with low pressure and apply the water directly to the soil. Automization of water supply and application of water on top of crops should be avoided to reduce evaporation losses;
- Irrigation management should ensure sufficient water for plant growth and efficient drainage to avoid problems of salinization;
- Irrigation water quality should be tested and monitored; when feasible, water desalinization should be performed;
- Surface and sub-surface drainage systems should be installed and maintained to control rising groundwater tables and control soil salinity. The design of these systems needs to be based on a thorough understanding of the water balance in these areas; and
- If soils are already degraded and prevention is no longer an option, reclamation of saline soils can be achieved using a variety of techniques such as direct leaching of salts, planting salt tolerant varieties, domestication of native wild halophytes for use in agro-pastoral systems, chemical amelioration and the use of organic amendments.

3.5 Prevent and minimize soil contamination

Soil may filter, fix and neutralize, but also release pollutants when conditions change (e.g. heavy metal release with lowering pH). Therefore, prevention of soil contamination remains the best way to maintain healthy soils and food safety in accordance to the Sustainable Development Goals.

Contaminants can enter soils from a variety of sources including agricultural inputs, land application of by-products, atmospheric deposition, flood and irrigation water, accidental spills, inappropriate urban waste and wastewater management, and other means. Accumulation and contamination occur if the rate of addition of a given contaminant exceeds its rate of removal from the soil system. Negative consequences may include plant toxicities and subsequent productivity declines, contamination of water and off-site areas through sediment transport, and increased human and animal health risks through accumulation in the food-chain.

- Governments are encouraged to establish and implement regulations to limit the accumulation of contaminants below established levels to safeguard human health and well-being, and facilitate remediation of contaminated soils that exceed these levels;
- Management of local soil contamination requires establishing background levels, followed by testing, monitoring and assessing contaminant levels to identify sites that are likely to be contaminated. Risk assessment, including total cost assessment, and remediation should be applied to reduce risks to humans and ecological systems;
- Identification of soils that are the most susceptible to the harmful effects of diffuse pollutants is needed. Appropriate attention should be given to reduce contaminant loads in these soils;

- Information on contaminated soil sites should be available to the public;
- Contaminated soils should not be used for food and feed production;
- Recycled nutrients originating from treated waste water or other waste materials that are used as soil amendments should be properly processed and tested to ensure they contain safe levels of contaminants and plant available nutrients. For instance, organic xenobiotics can pose a serious, incalculable and irreversible threat to soil fertility and human health; and
- Outflows of flood water from paddy rice cultivation after applying fertilizers and pesticides should be minimized to avoid off-site effects.

3.6 Prevent and minimize soil acidification

Human-induced acidification of agricultural and forest soils is primarily associated with removal of base cations and loss of soil buffering capacity or increases in nitrogen and sulfur inputs (e.g. legume pastures fertilizer inputs, atmospheric deposition). Soils with low pH-buffering capacity and/or high aluminium content are most prevalent when they have a low content of weatherable minerals (e.g. ancient, strongly weathered soils, and soils developed from quartz-rich parent materials).

- Monitoring soil acidity and minimizing surface and sub-surface soil acidity by using proper amendments (such as lime, gypsum and clean ash);
- Balanced fertilizer and organic amendment applications; and
- Appropriate use of acidifying fertilizer types.

3.7 Preserve and enhance soil biodiversity

Soils provide one of the largest reservoirs of biodiversity on earth, and soil organisms play key roles in the delivery of many ecosystems services. Little is known about the degree of biodiversity required to maintain core soil functions, but new tools for biochemical techniques and DNA analysis suggest significant progress in this area is possible.

- Monitoring programs for soil biodiversity, including biological indicators (e.g. community ecotoxicology) and in-situ early warning signals, should be undertaken;
- Soil organic matter levels supporting soil biodiversity should be maintained or enhanced through the provision of sufficient vegetative cover (e.g. cover crops, multiple crops), optimal nutrient additions, addition of diverse organic amendments, minimizing soil disturbance, avoiding salinization, and maintaining or restoring vegetation such as hedgerows and shelterbelts;
- The authorization and use of pesticides in agricultural systems should be based on the recommendations included in the International Code of Conduct on Pesticide Management and relevant national regulations. Integrated or organic pest management should be encouraged;
- The use of nitrogen fixing leguminous species, microbial inoculants, mycorrhizas (spores, hyphae, and root fragments), earthworms and other beneficial micro-, meso- and macro- soil organisms (e.g. beetle banks) should be encouraged where appropriate, with attention to limiting the risk of invasive processes by promoting the use of local biodiversity and avoiding the risk of disturbance in soil services;
- Restoring plant biodiversity in ecosystems, thereby favouring soil biodiversity;
- In-field crop rotation, inter-cropping, and preservation of field margins, hedges and biodiversity refuges should be encouraged; and

- Any land use change in areas with high biodiversity should be subject to land use planning and in line with the UNCBD, UNCCD and other relevant international instruments and with national law.

3.8 Minimize soil sealing

Land conversion and subsequent soil sealing for settlements and infrastructure affect all soils, but are of particular concern on productive, arable soils because of their importance for food production and food security and nutrition, and circular economy targets. In many places, urban sprawl affects the most productive soils adjacent to the cities and settlements. Soil sealing and land conversion causes a largely irreversible loss of some or all soil functions and the ecosystem services they provide.

- Considering the total value of soils and to ensure the preservation of productive, arable soils, existing policies, relevant laws and land use planning procedures for the development of settlements and infrastructure should be reviewed as appropriate;
- Where policy and legislation aim to minimize land conversion, measures should be implemented to encourage densification and re-use of existing urban or industrial areas such as abandoned areas and brownfields, and restoring degraded neighbourhoods after appropriate reclamation measures have been implemented. Ecological restoration of quarries and mining sites should be encouraged; and
- Soils with significant ecosystem services including high soil carbon stocks, high biological diversity or high agricultural suitability should be protected from land conversion for settlements and infrastructure by special legislation.

3.9 Prevent and mitigate soil compaction

Soil compaction is related to the degradation of soil structure due to imposed stresses by machinery and livestock trampling. Soil compaction (reduced or disrupted pore continuity) reduces soil aeration by destroying soil aggregates and collapsing macropore density, and reduces water drainage and infiltration, generating higher runoff. Compaction limits root growth and seed germination by high mechanical impedance, affecting soil biodiversity and causing surface soil crusting.

- Deterioration of soil structure due to inappropriate or excessive tillage should be prevented;
- Vehicular traffic should be minimized to the absolutely essential, particularly on bare soils, by reducing the number and frequency of operations, creating controlled traffic systems, and by performing agriculture/forestry operations only when the soil moisture content is suitable down to deeper depth;
- Machines and vehicles used in the field should be adjusted to soil strength and should be equipped with tyre pressure control systems or other means to reduce surface pressure (e.g. contact area), and use of heavy machinery should be avoided. During forestry operations, machine traffic should be restricted (e.g. controlled traffic) and brush mats used to help protect exposed soils from physical damage; on agricultural soils, controlled traffic and drive rows should be established, where possible;
- Cropping systems should be selected that include crops, pasture plants and, where appropriate, agroforestry plants with strong tap roots (dense and fibrous root systems) able to penetrate and break up compacted soils;
- An adequate amount of soil organic matter should be maintained to improve and stabilize soil structure;

- Macrofauna and microbial (especially fungal) activity should be promoted to improve soil porosity for soil aeration, water infiltration, heat transfer and root growth; and
- In grazing systems, a sufficient cover of growing plants should be maintained to protect the soil from trampling and erosion; livestock management should take into account grazing intensity and timing, animal types and stocking rates.

3.10 Improve soil water management

A sustainably managed soil has rapid water infiltration, optimal soil water storage of plant available water and efficient drainage when saturated. However, when these conditions are not met, waterlogging and water scarcity problems arise. On the one hand waterlogging, which is related to the saturation of soil with water, creates rooting problems for many plants, thereby reducing yields, and can cause contaminants such as arsenic and methylmercury to become mobile in the soil. On the other hand, water scarcity occurring in areas where water is lost by evaporation, surface runoff and percolation, can cause crop failure.

- In humid areas where precipitation exceeds evapotranspiration, additional drainage systems are needed to provide aeration for root functions like nutrient uptake. This is a concern especially in fine-textured soils which have high water retention capacity.
- Surface and sub-surface drainage systems should be installed and maintained to control rising groundwater tables in order to mitigate potential waterlogging;
- The efficiency of irrigation water use by plants should be increased through improved conveyance, distribution, and field application methods (e.g. scheduled drip or microsprinkler irrigation) that reduce evaporation and percolation losses of irrigation water, as well as through better soil water reserve estimation, better species or variety choices, and better computing of water loading periods and amounts;
- In dryland cropping systems, measures should be implemented to optimize water-use efficiency such as the management of soil cover (e.g. previous crops, forage and fallow) and water harvesting to increase soil water availability at sowing; reduction of runoff and evaporative losses from the soil surface; and ensuring that there is adequate water available at each stage of crop development. These measures often involve trade-offs and risks that should be recognized and managed;
- Optimal soil water extraction by the crop through the selection of appropriate cultivars and careful timing of agronomic operation should be promoted; and
- Regularly monitor irrigation water quality for nutrients and potential harmful substances



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4. Dissemination, use and evaluation of the VGSSM

Without prejudice to the voluntary nature of the present guidelines, all stakeholders are encouraged to promote, support and use the guidelines according to their respective individual or collective needs, mandates, abilities, and relevant national contexts. The successful use of the guidelines needs a collective action of multiple stakeholders in an inclusive, participatory, gender sensitive, cost-effective and sustainable manner. In doing so, evidence-based scientific knowledge as well as local knowledge should be used as appropriate.

Acknowledging that States have the primary responsibility for achieving food security and nutrition of their population, they are encouraged to:

- Take the lead in promoting the use and evaluation of the VGSSM;
- Set up relevant platforms and frameworks, as appropriate, for collective action at local, national and regional levels, or use the existing facilities to promote these voluntary guidelines;
- Promote effective extension services that rely on proper research and education institutions and mainstream SSM in their activities; and
- Evaluate their use and the impact of improved soil management on food security, ecosystem services related to soil functions and on the efforts towards achieving the Sustainable Development Goals.

In this endeavour, States may seek technical support from FAO or other international and regional bodies, as appropriate. The Regional and Sub-Regional Soil Partnerships are instrumental in disseminating and promoting the use of the VGSSM.

Development partners, relevant specialized agencies and programmes of the United Nations, international financial institutions and regional organizations are encouraged to:

- Support the dissemination and implementation of these voluntary guidelines; and
- Facilitate, as appropriate, technical cooperation, financial assistance, capacity development, knowledge sharing and transfer of technology aimed at promoting SSM.

For other stakeholders, the following is suggested:

- Private sector enterprises involved in soil management are invited to promote the use of the guidelines with a focus on managing risks to maximize positive and minimize negative impacts on SSM, relevant to their context and circumstances;
- Civil society organizations with relevance to soil management are invited to integrate the guidelines in their policies and programmes, advocate for the appropriate use of the guidelines and assist with building capacity of their members with the aim of contributing to SSM; and
- Research organizations, universities, academia, extension organizations and/or programmes are invited to promote integration of the guidelines in their own policies, and facilitate knowledge exchange and skills development to contribute to SSM.

The GSP, hosted by FAO, presents a global forum where different stakeholders learn from each other's experiences and assess progress toward the implementation of these guidelines and their relevance, effectiveness and impact. The GSP Secretariat and the Intergovernmental

Technical Panel on Soils (ITPS) as its advisory body will report to the GSP Plenary Assembly on the progress in the implementation of the guidelines, as well as evaluate their impact and their contribution to the improvement of soil management.

Dissemination and promotion of the guidelines at the regional level should be supported by all stakeholders, particularly through the Regional Soil Partnerships.

In promoting the use of the VGSSM, possible synergies and collaboration with other relevant initiatives related to sustainable soil management could be explored.



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Ministry of Finance of the Russian Federation



European Commission

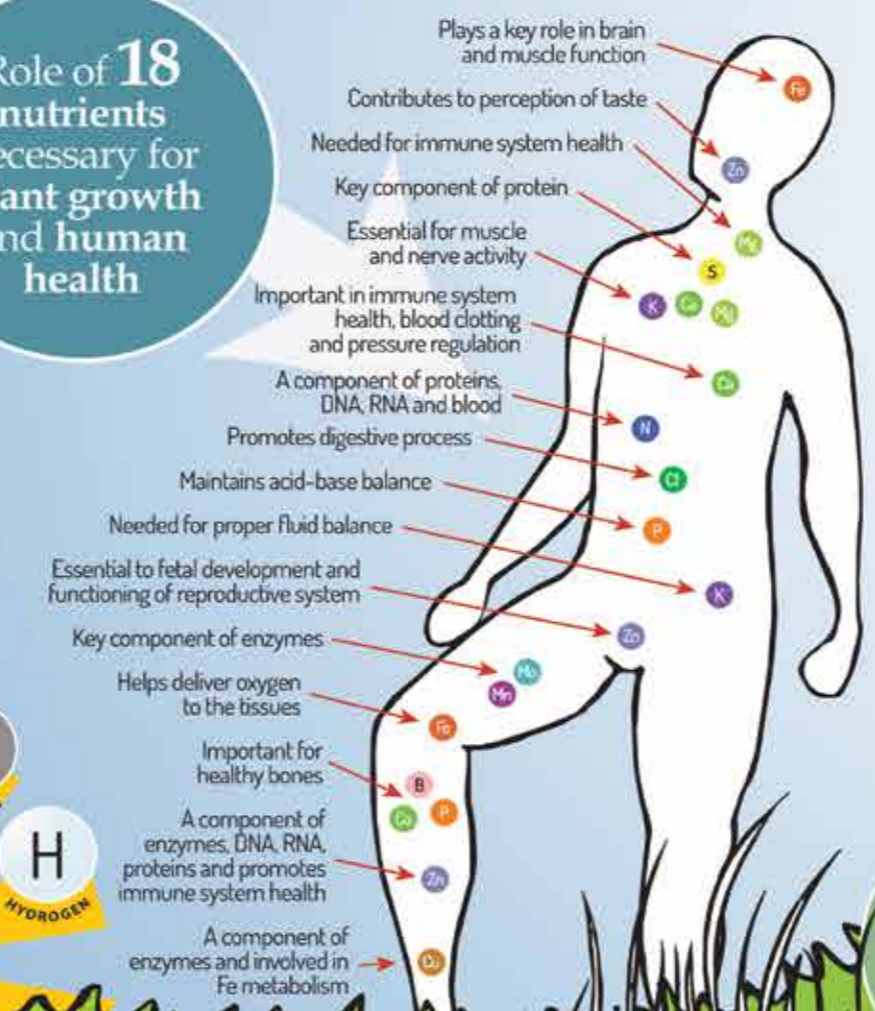
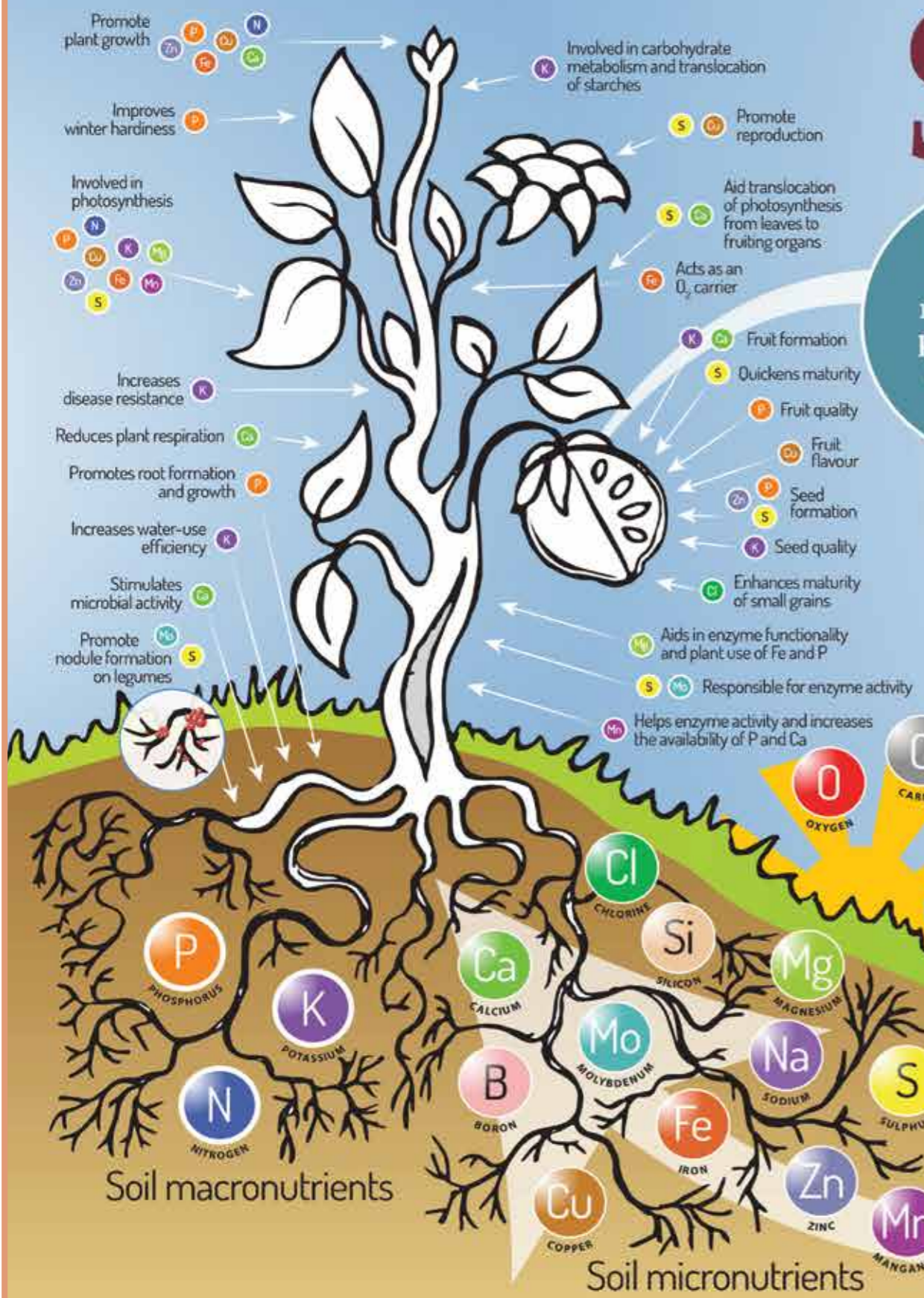


ANNEXURE II

Infographs for Highlighting the Significance of Healthy Soils

Soil the foundation of nutrition

Role of 18 nutrients necessary for plant growth and human health



Soil degradation leads to the loss of soil micro and macronutrients

Nutrient-poor soils are unable to produce healthy food with all the necessary nutrients for a healthy person

Over 2 billion people suffer from micronutrient deficiencies



SOIL IS A NON-RENEWABLE RESOURCE



2050 THE CHALLENGE

Global population will exceed 9 billion

agricultural production increases

60% globally

100% developing countries

Increased demand for healthier and nutritious food will only be met if

Soils are under pressure of intensification and competing uses of forestry, cropping, pasture & urbanization

OUR SOILS TODAY

33% of global soil is moderately to highly degraded through erosion, salinization, compaction, acidification & chemical pollution & nutrient depletion hampering soils functions and affecting food production

83% of rural people in Sub-Saharan Africa depend on their land for livelihood

40% of Africa's soils are currently degraded

In most countries there is little opportunity for expansion of arable land

SAVING OUR SOILS

Sustainable soil management

- Inclusive policies and governance
- Investment in sustainable soil management
- Targeted soil research
- Stopping soil degradation & restoring degraded soils
- Effective education & extension programmes
- Soil information systems

Increasing soil organic matter content

Keeping soil surface vegetated

Using nutrients wisely

Promoting crop rotations

Reducing erosion

can lead to an average crop yield increase of 58%

SOILS ARE THE FOUNDATION FOR VEGETATION

Fertile soil supports plant growth by providing plants with nutrients, acting as a water holding tank, and serving as the substrate to which plants anchor their roots

Vegetation, tree cover and forests prevent soil degradation and desertification by stabilizing the soil, maintaining water and nutrient cycling, and reducing water and wind erosion

SOILS AND CROPS

Food security and nutrition rely on healthy soils.

The nutrient content of a plant's tissues is directly related to the nutrient content of the soil and its ability to exchange nutrients and water with the plant's roots.

Crops protect soil against soil erosion agents (e.g. water and wind) and improve soil structure by:

- rooting
- enriching soil nutrients by providing organic matter
- establishing symbiotic relationships with soil bacteria

Nutrient depletion takes place in intensive agricultural systems and is linked to the practice of monoculture.

Crop rotation is critical to preserving and eventually improving soil health.

SOILS AND PASTURE

Grasses found on pasturelands protect the soil against soil erosion and support soil biological activities.

The livestock sector provides food and income for 1 billion of the world's poor.

26% of the earth's terrestrial surface is occupied by grazing

Grazing and overgrazing remove the soil cover, lowering soil erosion, and reducing important soil functions such as climate regulation.

Grass type and pasture rotation help keep the soil system functional.

As global demand for meat and dairy products continues to rise, soil protection and conservation on pasturelands becomes even more critical.

SOILS AND FORESTS

Forests provide livelihoods for more than 1 billion people and are vital for conservation of biodiversity, energy supply, and soil and water protection.

Nearly 1/3 of the total carbon in terrestrial ecosystems is contained in forests.

The use of solid biofuels, including wood, is predicted to grow, along with the expansion of agricultural lands putting at risk the capacity of forest soils to act as carbon sinks in the future.

As a result of the conversion of forests and native grasslands to croplands, the soil's capacity to act as a carbon sink can decrease by 20-40%

Sustainable soil management is important to address the growing food demand caused by population growth.

SOILS STORE AND FILTER WATER

Soils improve food security and our resilience to floods and droughts

What is soil moisture?

Soil moisture content is the amount of water in the soil (by weight).

The maximum amount of water that a soil can retain depends on:

- the soil's texture and structure
- organic matter content
- rooting depth

healthy soils with a high organic matter content can store large amounts of water. This is crucial for maintaining food production while also improving resilience to floods and droughts.

Soil organic matter can retain about 20 times its weight in water.

Soil moisture and food security

Water is the "lifeblood" of agriculture—improved soil moisture management is critical for sustainable food production.

Inhibiting a soil's capacity to accept, retain, release and transmit water reduces its productivity.

The great challenge for the future will be increasing food production with less water

As most smallholder farmers in developing countries rely on rain-fed agriculture, improved soil moisture optimization and management is crucial.

Over cultivation, overgrazing and deforestation strain soil and water resources by reducing topsoil and vegetation cover, and lead to dependence on irrigated cropping.

Meeting food security targets requires sustainable agricultural policies that ensure improved soil quality and water retention.

Improving soil moisture

Many sustainable agricultural and land management practices can improve soil moisture retention:

- Residue covers, cover crops and mulching
- Conservation agriculture
- Knowledge-based precision irrigation
- Conservation tillage
- Capture of runoff from adjacent lands
- Efficient use of water, reduced use of pesticides and improvements in soil health can lead to average crop yield increases of 79%
- Zero-tillage
- Rainwater harvesting





ANNEXURE III

Questionnaire of Inputs Use Assessment (2018)
[English, Urdu]

Inputs Use Assessment for Khyber Pakhtunkhwa (2018)

Farmer Name: ----- CNIC: -----

Address: ----- Tehsil & District: -----

Land available at farm (acre): ----- Cultivated (acre): -----

Reason if less area is cultivated: -----

Contact No.: ----- Signature: -----

A. Fertilizer Use (bags/acre) or (kg/tree)

Commodity	Nitrogen		Phosphorus				Potash		Micronutrients		Other
	Urea	CAN	DAP	MAP	SSP	NP	MoP	SoP	Zinc Sulphate	Boron	*FYM/GM/CRI
Crops	----- bags / acre -----								--- kg / acre ---		-- ton/acre --
Wheat											
Rice											
Cotton											
Sugarcane											
Maize											
Tobacco											
Others											
Fruit crops	----- kg / tree -----								--- g / tree ---		kg / tree
Peach											
Plum											
Pear											
Pomegranate											
Others											
Vegetables	----- bags / acre -----								--- kg / acre ---		-- ton/acre --
Tomato											
Potato											
Chilli											
Others											

*Farmyard Manure/Green Manure/Crop Residue incorporation (if any)

B. How many other farmers in family / neighbors use similar rates of the fertilizers / management practices and they obtain similar yields?

Family farmers Neighbor farmers

C. According to your experience / opinion, what are the best practices for increasing the crop yield / soil quality?

1. ----- 2. ----- 3. -----

D. Irrigation Sources:

Irrigated		Rainfed <input type="checkbox"/>
Canal <input type="checkbox"/>	Tube well <input type="checkbox"/>	
Irrigation method for canal and tubewell water		Is rainfall sufficient for crop (YES or NO)

E. Laboratory Analysis (prior to sowing):

Soil Test <input type="checkbox"/>	Water Test <input type="checkbox"/>
Did you consult the agriculture extension staff and how often? Yes <input type="checkbox"/> No <input type="checkbox"/>	Is the agriculture extension staff easily accessible? Yes <input type="checkbox"/> No <input type="checkbox"/>

F. Farm Machinery:

Type ----- Ownership ----- Rental -----

G. Yield (Maunds/acre)

Wheat	Rice	Cotton	Sugarcane	Maize	Barley	Fruit Crops	Vegetables

H. Satisfied with fertilizer/commodities price:

YES <input type="checkbox"/>	NO <input type="checkbox"/>
------------------------------	-----------------------------

I. Major Problems:

Soil-related Constraints

Water scarcity <input type="checkbox"/>	Salinity <input type="checkbox"/>	Sodicity <input type="checkbox"/>	Other <input type="checkbox"/>
---	-----------------------------------	-----------------------------------	--------------------------------

Non Soil-related Constraints

Pests and Diseases <input type="checkbox"/>	Quality Seed <input type="checkbox"/>	Agric. Loans <input type="checkbox"/>	Others <input type="checkbox"/>
---	---------------------------------------	---------------------------------------	---------------------------------

J. Any Comments/Suggestions

کھادوں کے استعمال سے متعلق سوالنامہ (۲۰۱۸)

صوبہ خیبر پختونخوا

نام کسان _____ فون نمبر _____

پتہ _____ تحصیل و ضلع _____

فارم کا کل رقبہ (ایکڑ) _____ زیر کاشت رقبہ (ایکڑ) _____

باقی رقبہ نہ کاشت کرنے کی وجہ اور جوہات _____

دستخط _____

کھادوں کا استعمال (تھیلے فی ایکڑ) (کلوگرام فی ایکڑ)

نام	رقبہ	ناٹروجن			فسفورس			پوٹاش		مائیکرو نیوٹریٹس		گورڈیگرہ کی کھاد / سبز کھاد / فصل کوزمین میں ملا دینا
		بوریا	سی اے این	ڈی اے پی	ایم اے پی	ایس ایس پی	این پی	ایم او پی	ایس او پی	بوران	زنک سلفیٹ	
فصل / فصلات	ایکڑ											ٹن فی ایکڑ
باغ / باغات	ایکڑ											کلوگرام فی درخت
سبزی / سبزیات												ٹن فی ایکڑ

۲۔ فصل کی پیداوار (من فی ایکڑ)

نام فصل	پیداوار

۳۔ پھلوں کی پیداوار (من فی ایکڑ)

نام پھل	پیداوار

۴۔ آپ کے خاندان یا ہمسایوں کی ملکیت کتنے فارم ہیں جو آپ جیسے کاشت کے طریقے اور کھاد استعمال کرتے ہیں اور آپ جیسی پیداوار حاصل کرتے ہیں؟

خاندان کے فارم / فارمز ہمسایوں کے فارم / فارمز

۵۔ آپ کے تجربہ ارائے کے مطابق فصل کی پیداوار / زمین کا معیار بڑھانے کے لئے کونسے طریقے بہترین ہیں۔

_____ 1 _____ 2 _____ 3

۶۔ زرعی آپاش

آپ پاش رقبہ	
<input type="checkbox"/> نہری	<input type="checkbox"/> ٹوب ویل

۷۔ آپ کونسے زرعی آلات / مشینری استعمال کرتے ہیں؟

_____ 1 _____ 2 _____ 3

آپ کے ذاتی ہیں کرایہ پر لیتے ہیں

۸۔ i کیا آپ زمین کا تجزیہ کرواتے ہیں؟ ہاں نہیں ii کیا آپ پانی کا تجزیہ کرواتے ہیں؟ ہاں نہیں

۹۔ i کیا آپ زرعی ماہرین سے مشورہ کرتے ہیں؟ ہاں نہیں ii کیا ان تک رسائی ممکن ہیں؟ ہاں نہیں

۱۰۔ کیا آپ قیمتوں / منڈی کے نظام سے مطمئن ہیں؟

i کھاد ہاں نہیں ii اجناس ہاں نہیں

۱۱۔ کاشتکاری اور بہتر پیداوار سے متعلقہ مسائل

i پانی کی کمی ہاں نہیں ii سیم و تھور ہاں نہیں

iii منظور شدہ اقسام کے معیاری بیج کی دستیابی ہاں نہیں iv زرعی قرضہ جات ہاں نہیں

v کوئی اور مشکل یا وجہ ہاں نہیں

۱۲۔ کوئی تجویز، مشورہ یا تبصرہ



ANNEXURE IV

ANNEXURE IV (a): DISTRICT WISE RESULTS OF THE SOIL SAMPLES ANALYZED BY FFC

District/City	Soil Parameter	Range (Minimum-Maximum)	Fertility Status/Class	District	Soil Parameter	Range (Minimum-Maximum)	Fertility Status/Class
ABBOTTABAD	¹ pH	6.84-8.80	Alkaline	KOHAT	pH	7.48-8.90	Alkaline
	¹ Electrical Conductivity (dS m ⁻¹)	0.1-2.63	Saline		Electrical Conductivity (dS m ⁻¹)	0.1-13.2	Saline
	² Organic Matter (%)	0.3-3.23	Medium		Organic Matter (%)	0.17-1.75	Low
	³ Available Phosphorus (ppm)	1.0-15.0	Low		Available Phosphorus (ppm)	2.0-18.0	Low
	⁴ Extractable Potassium (ppm)	42-400	Adequate		Extractable Potassium (ppm)	52-640	Medium
BANNU	pH	8.0-8.4	Alkaline	MANSEHRA	pH	3.40-8.22	Acidic - Alkaline
	Electrical Conductivity (dS m ⁻¹)	0.41-3.91	Saline		Electrical Conductivity (dS m ⁻¹)	0.05-0.95	Normal
	Organic Matter (%)	0.5-1.29	Low		Organic Matter (%)	0.18-2.60	Medium
	Available Phosphorus (ppm)	6.0-10.0	Low		Available Phosphorus (ppm)	1.0-40.0	Low
	Extractable Potassium (ppm)	180-730	Adequate		Extractable Potassium (ppm)	34-690	Medium
Buner	pH	7.33-8.22	Alkaline	NOWSHERA	pH	7.0-10.1	Alkaline
	Electrical Conductivity (dS m ⁻¹)	0.08-0.17	Normal		Electrical Conductivity (dS m ⁻¹)	0.06-7.8	Saline
	Organic Matter (%)	0.73-1.36	Medium		Organic Matter (%)	0.1-1.98	Medium
	Available Phosphorus (ppm)	3.0-10.0	Low		Available Phosphorus (ppm)	1.0-26.0	Low
	Extractable Potassium (ppm)	46-178	Low-Medium		Extractable Potassium (ppm)	16-710	Medium
CHARSADDA	pH	6.20-10.40	Alkaline	PESHAWAR	pH	7.4-10.4	Alkaline
	Electrical Conductivity (dS m ⁻¹)	0.04-5.88	Saline		Electrical Conductivity (dS m ⁻¹)	0.05-22.3	Saline
	Organic Matter (%)	0.1-2.72	Medium		Organic Matter (%)	0.1-2.72	Medium
	Available Phosphorus (ppm)	1.0-45.0	Medium		Available Phosphorus (ppm)	1.0-62.0	Low
	Extractable Potassium (ppm)	50-830	Medium		Extractable Potassium (ppm)	10-780	Medium
DERA ISMAIL KHAN	pH	7.29-9.60	Alkaline	SWABI	pH	5.96-9.85	Acidic - Alkaline
	Electrical Conductivity (dS m ⁻¹)	0.07-12.84	Saline		Electrical Conductivity (dS m ⁻¹)	0.04-2.56	Slightly saline
	Organic Matter (%)	0.1-1.66	Medium		Organic Matter (%)	0.1-2.0	Medium
	Available Phosphorus (ppm)	1.0-20.0	Low		Available Phosphorus (ppm)	1.0-19.0	Low
	Extractable Potassium (ppm)	60-1240	Medium		Extractable Potassium (ppm)	40-660	Medium
DIR UPPER	pH	7.0-8.3	Alkaline	SWAT	pH	6.1-8.2	Acidic - Alkaline
	Electrical Conductivity (dS m ⁻¹)	0.05-0.32	Normal		Electrical Conductivity (dS m ⁻¹)	0.1-0.29	Normal
	Organic Matter (%)	0.17-1.17	Medium		Organic Matter (%)	0.16-2.13	Medium
	Available Phosphorus (ppm)	2.0-20.0	Low		Available Phosphorus (ppm)	2.0-15.0	Low
	Extractable Potassium (ppm)	50-310	Medium		Extractable Potassium (ppm)	60-380	Medium
HARIPUR	pH	6.02-9.90	Alkaline	TANK	pH	7.8-8.6	Alkaline
	Electrical Conductivity (dS m ⁻¹)	0.05-3.59	Saline		Electrical Conductivity (dS m ⁻¹)	0.13-3.45	Slightly Saline
	Organic Matter (%)	0.1-2.24	Low		Organic Matter (%)	0.37-1.12	Low
	Available Phosphorus (ppm)	1.0-36.0	Low		Available Phosphorus (ppm)	2.0-5.0	Low
	Extractable Potassium (ppm)	14-700	Medium		Extractable Potassium (ppm)	100-640	Medium

Soil pH and electrical conductivity were measured in 1:2.5, soil:water extract; Soil organic matter was determined using Walkley (1947) method; Soil available-phosphorus was measured using Olsen and Watanable (1954) method; Soil extractable-potassium was determined using Berg and Gardner (1978) method. Soil fertility status/class (based on criteria set by Soil Fertility Research Institute, Punjab) in respective districts has been defined based on majority trend of the analysed test sample results.

ANNEXURE IV (b): CRITERIA FOR INTERPRETATION OF SOIL ANALYSIS RESULTS

DIRECTORATES OF AGRICULTURE RESEARCH AND EXTENSION, KHYBER PAKHTUNKHWA

Nutrient/Organic Matter	Test	Low	Marginal	Adequate
Organic Matter	Walkley-Black Method (%)	< 0.86	0.86 – 0.29	>1.29
Phosphorus	NaHCO ₃	<8	8 – 15	>15
Potassium	NH ₄ OAc	<100	100 – 150	>150
Zinc	DTPA	<0.5	0.5 – 1.0	>1.0
	AB-DTPA	<4	4 – 7	>7
Copper	DTPA	<0.2	0.2 – 0.5	>1.5
	AB-DTPA	<1.0	1.0 – 1.5	>1.5
Manganese	DTPA	<1.0	1.0 – 2.0	>2.0
Boron	HCl	<0.45	0.45 – 1.0	>1.0
Iron	DTPA	<4.5		>4.5
	AB-DTPA	<0.2		>0.5

(Source: ICARDA Manual 2015)

Soil parameter	FFC	
	Status	Value
pH	Acidic	<6.5
	Neutral	6.5 – 7.5
	Alkaline	>7.5
Electric Conductivity (dS m ⁻¹)	Normal	<0.5
	Slight Saline	0.5 – 1.0
	Saline	>1.0
Organic Matter (%)	Very Low	<0.5
	Low	0.5 – 1.0
	Medium	1.01 – 1.5
	High	1.5 – 2.0
	Very High	>2
Available P (ppm)	Very Low	<5
	Low	6 – 10
	Medium	11 – 15
	High	16 – 20
	Very High	20 – 25
Extractable Potassium (ppm)	Extremely High	>25
	Very Low	<50
	Low	51 – 100
	Medium	101 – 150
	High	151 – 200
	Very High	201 – 300
	Extremely High	>300

*Soil pH and Electrical Conductivity are measured in 1:2.5, soil:water extract

(Source: Fauji Fertilizer Company Limited)



ANNEXURE V

ADDRESSES OF SOIL AND WATER TESTING FACILITIES IN KHYBER PAKHTUNKHWA

Soil Testing Facility	District	Address
The Univeristy of Agriculture, Peshawar	Peshawar	Soil and Water Testing Laboratory, Department of Environmental Sciences
	Peshawar	Soil Testing Laboratory, Department of Geology
	Peshawar	Soil Testing Laboratory, Centralized Resource Laboratory
	Peshawar	Soil and Water Testing Laboratory, Department of water management
Pakistan Forest Institute	Peshawar	Soil Testing Laboratory, Pakistan Forest institute Peshawar
EPA	Peshawar	Soil and Water Testing Laboratory, Environmental Protection Agency, Peshawar
PCSIR	Peshawar	PCSIR Laboratories Peshawar
Pakistan Agriculture Research	Kaghan	Summer Agricultural Research Station (SARS) Kaghan
	Gilgit	Mountain Agricultural Research Centre (MARC) Gilgit.
	Manshera	National Tea and High Value Crops Research Institute, Shankiari Manshera.
Pakistan Tobacco Board	Mardan	Tobacco Research Station, Mardan
NIFA	Peshawar	Division of Soil and Environmental Sciences, NIFA Peshwar
Model Farm Services District Lab	Abbottabad	Near Missile Chowk Opposite Allied Bank Jinnah Abad Branch Mandian Abbottabad
	Bannu	Near Office of the District Director, Agriculture Bannu
	Battagram	Adjacent to the Office of District Director Agriculture Battagram
	Buner	Office of the District Director Model Farm Services Center Tehsil Colony Daggar Buner
	Charsadda	Near Office of the District Director, Agriculture Charsadda
	Chitral	Near Office of District Director Agriculture Extension Chitral
	Dera Ismail Khan	Model Farm Service Center Bannu Road, D.I. Khan Near Bab-e-Dera Bannu Road, D.I.Khan
	Hangu	Near Office of the District Director, Agriculture Hangu
	Haripur	Near Office of the District Director, Agriculture Haripur
	Karak	Near District Director Agriculture office Bannu Road Tappi Karak
	Kohat	Near Office of District Director Agriculture Extension Kohat
	Kohistan	Near office of agriculture extension, Kohistan
	Lakki Marwat	Office of District Director Agriculture Lakki Marwat Larri Ada
	Lower Dir	Model Farm Services Center Shaheed Chowk / Plaza, By Pass Road, Timergara Dir lower
	Malakand	Near Office of the District Director, Agriculture Malakand
	Mansehra	Near Office Of The District Director Agriculture Extension Manshera
	Mardan	Near Office of District Director Agriculture Extension Mardan
	Nowshera	Near Office of the District Director, Agriculture Nowshera
	Peshawar	Near Office of the District Director Agriculture Peshawar
	Shangla	Office of the District Director, Agriculture Shangla
Swabi	Office of the District Director, Agriculture Swabi	
Swat	District Director Agriculture Extension Department Model Farm Service Center, Swat	
Tank	District Director Agriculture Extension Mission Road Tank	
Tor Ghar	Office of Agriculture Extension, Torghar	
Upper Dir	OFFICE OF THE DISTRICT DIRECTOR AGRICULTURE DIR UPPER MFSC	
Research Stations/Institutes	Peshawar	Agricultural Research Institute Tarnab, Peshawar
	Nowshera	Cereal Crops Research Institute, PirsabakNowshera
	Mardan	Sugar Crops Research Institute, Mardan
	Swat	Agricultural Research Institute, Mingora Swat
	Kohat	Barani Agricultural Research Station, Kohat
	Abbottabad	Hazara Agriculture Research Station, Abbotabad
	Mansehra	Agriculture Research Station, Baffa, Mansehra
	Buner	Agricultural Research Station, Amnawar, Buner
	Swabi	Agriculture Research Station, Swabi
	Chitral	Agricultural Research Station, Chitral
	Karak	Agricultural Research Station, Ahmad Wala, Karak
	Dera Ismail Khan	Agricultural Research Institute, D.I. Khan
	Bannu	Agriculture Research Station, Bannu
	Bannu	Agricultural Research Station, SeraiNaurang (Bannu)
	Charsadda	Agricultural Research Station, Harichand Charsadda
	FATA	Soil and Water Testing Laboratory, Agricultural Research, Parachinar, FATA

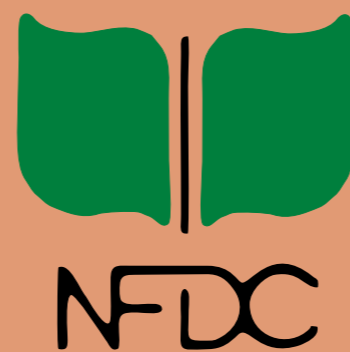
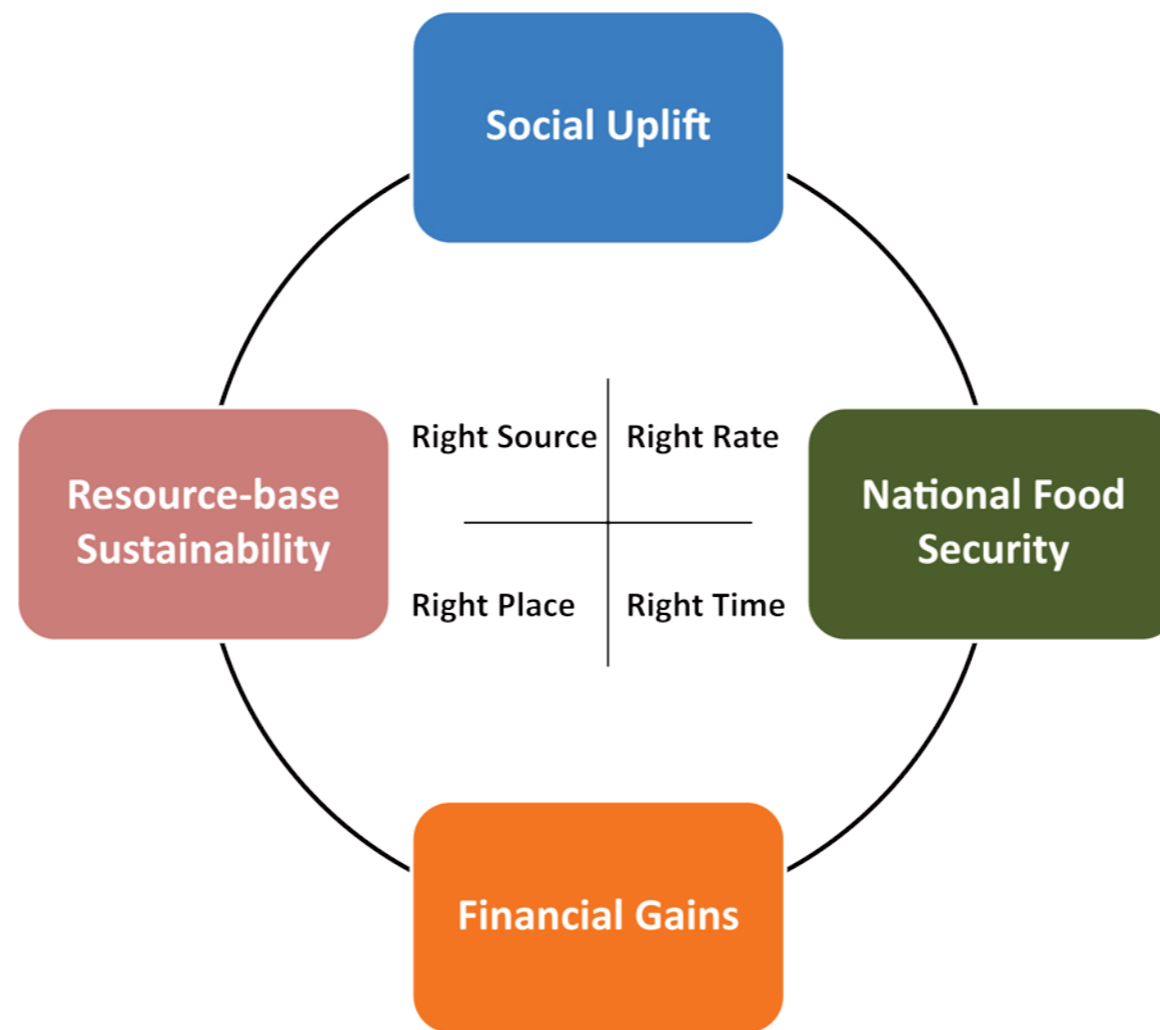
The background is a topographic map of a region, likely in the Himalayas, showing a prominent mountain range running north-south. The terrain is rugged with numerous peaks, ridges, and valleys. The color scheme is a monochromatic brown/orange, where darker shades indicate higher elevations and lighter shades indicate lower elevations. The map shows a complex network of mountain ridges and deep valleys, with a major range running vertically through the center. The overall appearance is that of a detailed topographic relief map.

ANNEXURE VI

Dominant Soil Series, Classification and Areas of Occurrence

ANNEXURE VI: DOMINANT SOIL SERIES, CLASSIFICATION AND AREAS OF OCCURRENCE IN KHYBER PAKHTUNKHWA

S.NO	Soil Series	FAO - UNESCO World Soil Map	US Soil Taxonomy	Area of Occurrence	S.NO	Soil Series	FAO - UNESCO World Soil Map	US Soil Taxonomy	Area of Occurrence
1	Abbakhel	Calcaric Fluvisols	Vertic Ustic Torripsamments	Bannu	46	Minakhel	Haplic Yermosols	Typic Calciorrhids	Kohat
2	Bahatar	Calcaric Cambisols	Typic Ustochrepts	Peshawar	47	Missa	Haplic Yermosols / Calcaric Cambisols	Typic Calciorrhids / Typic Ustochrepts	Peshawar
3	Balkassar	Haplic Yermosols / Calcaric Cambisols	Typic Camborthids / Typic Ustochrepts	Peshawar	48	Misri	Haplic Yermosols	Halic Camborthids	Peshawar
4	Bhola	Haplic Yermosols	Halic Camborthids	Peshawar	49	Munghalki	Haplic Yermosols	Fluventic Camborthids	Peshawar
5	Bhutesar	Haplic Yermosols	Typic Camborthids	Dera Ismail Khan	50	Naivela	Calcaric Fluvisols	Typic Torriorthents	Dera Ismail Khan
6	Burhan	Calcaric Cambisols	Typic Ustochrepts	Peshawar	51	Notak	Haplic Yermosols	Typic Camborthids	Dera Ismail Khan
7	Buzdar	Calcaric Fluvisols	Typic Torriorthents	Dera Ismail Khan	52	Parachinar	Eutric Cambisols	Typic Ustochrepts	Kohat
8	Chamkani	Haplic Yermosols	Typic Camborthids	Peshawar	53	Peshawar	Haplic Yermosols	Fluventic Camborthids	Peshawar
9	Changhos	Haplic Yermosols	Typic Camborthids	Kohat, Bannu	54	Pewar	Calcaric Cambisols	Typic Ustochrepts	Kohat
10	Charsadda	Eutric Cambisols	Aeric Haplaquepts / Aquic Ustochrepts	Peshawar	55	Pindorian	Eutric Cambisols	Typic Ustochrepts	Peshawar, Kohat
11	China	Eutric Cambisols	Aeric Haplaquepts / Aquic Ustochrepts	Peshawar	56	Pirsabak	Haplic Yermosols	Typic Camborthids	Peshawar
12	Chirri	Haplic Yermosols	Typic Camborthids	Dera Ismail Khan	57	Qazian	Calcaric Rhegosols	Lithic Torripsamments	Peshawar
13	Dargai	Typic Camborthids	Typic Camborthids	Peshawar	58	Qutbal	Calcaric Rhegosols	Typic Ustorthents	Peshawar
14	Dhulian	Calcaric Cambisols	Typic Ustochrepts	Peshawar	59	Rajar	Calcaric Rhegosols	Typic Ustorthents & Typic Torriorthents	Peshawar
15	Dosera	Calcaric Cambisols	Typic Ustochrepts	Peshawar	60	Ramak	Haplic Yermosols	Vertic Camborthids	Dera Ismail Khan
16	Ghaznikhel	Calcaric Fluvisols	Typic Torripsamment	Bannu	61	Rustam	Calcaric Fluvisols	Typic Torriorthents or Typic Torrifluvents	Dera Ismail Khan
17	Ghoriwala	Haplic Yermosols/ Calcaric Gleysols	Aquic Camborthids/ Typic Camborthids	Bannu	62	Saggu	Haplic Yermosols	Vertic Camborthids	Dera Ismail Khan
18	Gishkori	Haplic Yermosols	Typic Camborthids	Dera Ismail Khan	63	Sakhakot	Eutric Cambisols	Typic Ustochrepts	Peshawar
19	Guliana	Eurtic Cambisols	Typic Ustochrepts	Peshawar	64	Sardheri	Haplic Yermosols	Aquic Camborthids	Peshawar
20	Hangu	Haplic Xerosols	Typic Ustochrepts	Kohat	65	Shabqadar	Calcaric Gleysols	Aeric Vertic Haplaquepts	Peshawar
21	Janikhel	Haplic Yermosols	Typic Camborthids	Bannu	66	Shahdara	Calcaric Fluvisols	Typic Ustifluvents / Torrifluvents	Dera Ismail Khan
22	Kachori	Haplic Yermosols	Halic Camborthids	Peshawar	67	Shakardara	Haplic Yermosols	Typic Camborthids	Kohat
23	Kalpani	Haplic Yermosols	Fluventic Camborthids	Peshawar	68	Shalozan	Eutric Cambisols	Typic Ustochrepts	Kohat
24	Kashu	Haplic Yermosols / Haplic Xerosols	Typic Camborthids	Bannu	69	Shehbazgarhi	Calcaric Cambisols	Typic Ustochrepts	Peshawar
25	Kasur	Orthic Solonchaks / Gleysic Solonchaks	Halic Ustorthents / Halic Torriorthents	Dera Ismail Khan	70	Spenkanra	Haplic Yermosols	Halic Camborthids	Peshawar
26	Kattikhel	Haplic Yermosols	Halic Camborthids	Peshawar	71	Sultanpur	Haplic Yermosols	Typic Camborthids	Dera Ismail Khan
27	Khair	Calcaric Fluvisols	Typic Torriorthents / Typic Ustorthents	Dera Ismail Khan	72	Tajori	Haplic Yermosols	Typic Camborthids	Bannu
28	Khairukhel	Haplic Yermosols	Fluventic Camborthids	Bannu	73	Takhtikhel	Calcaric Fluvisols	Typic Torri fluvents	Bannu
29	Khazana	Calcaric Fluvisols / Calcaric Gleysols	Aquic Ustipsamments	Peshawar	74	Talai	Calcaric Fluvisols	Typic Torripsamments	Dera Ismail Khan
30	Khojak	Haplic Yermosols	Fluventic Camborthids	Bannu	75	Tangi	Calcaric Cambisols	Typic Xerochrepts / Typic Ustochrepts	Peshawar
31	Kirman	Calcaric Cambisols	Typic Ustochrepts	Kohat	76	Tarkhoba	Haplic Yermosols	Typic Camborthids	Kohat, Bannu
32	Kohat	Haplic Yermosols	Typic Camborthids	Kohat	77	Tarnab	Haplic Yermosols	Typic Camborthids	Peshawar
33	Kot	Haplic Yermosols	Typic Camborthids	Peshawar	78	Taru	Haplic Yermosols	Typic Camborthids	Peshawar
34	Kufri	Calcaric Cambisols	Typic Ustochrepts	Peshawar	79	Thall	Calcaric Cambisols	Typic Ustochrept	Kohat
35	Kunda	Eurtic Fluvisols	Typic Ustipsamments	Peshawar	80	Thatti	Haplic Yermosols	Typic Camborthids	Bannu
36	Lachi	Haplic Yermosols	Typic Camborthids	Kohat	81	Tikken	Calcaric Fluvisols	Typic Torriorthents	Dera Ismail Khan
37	Lakki	Haplic Yermosols	Typic Camborthids	Bannu	82	Tochi	Haplic Yermosols	Fluventic Camborthids	Bannu
38	Mackeson	Haplic Yermosols	Fluventic Camborthids	Peshawar	83	Toru	Calcaric Fluvisols	Aquic Xerorthents / Aquic Ustorthents	Peshawar
39	Malik	Calcaric Fluvisols	Typic Torriorthents/Typic Ustorthents	Dera Ismail Khan	84	Turtola	Orthic Solonchaks	Vertic Camborthids	Kohat, Bannu
40	Malikshahi	Haplic Yermosols	Typic Camborthids	Bannu	85	Wajan	Calcaric Rhegosols	Typic Torripsamments	Dera Ismail Khan
41	Mansehra	Eutric Cambisols	Typic Eutrochrepts	Mansehra, Peshawar	86	Warsak	Haplic Yermosols	Fluventic Camborthids	Peshawar
42	Mansooka	Calcaric Cambisols / Haplic Xerosols	Typic Ustochrepts / Fluventic Camborthids	Peshawar	87	Zaramiani	Eutric Cambisols	Typic Ustochrepts	Peshawar
43	Mardan	Calcaric cambisols	Vertic Ustochrepts / Vertic Camborthids	Peshawar	88	Zeran	Eutric Cambisols	Typic Ustochrepts	Kohat
44	Marghuz	Calcaric Gleysols	Aeric Haplaquents	Peshawar	89	Zindani	Calcaric Fluvisols	Typic Torriorthents	Dera Ismail Khan
45	Milward	Haplic Yermosols / Haplic Xerosols	Typic Calciorrhids	Peshawar					



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