FARMING-SYSTEM SPECIFIC EXTENSION CONTENT FOR ENHANCING CLIMATE CHANGE ADAPTATION AND RESILIENT FOOD SYSTEMS IN SORGHUM-BASED DRYLAND FARMING SYSTEMS OF TANZANIA AND BURKINA FASO

CONSERVATION AGRICULTURE

CLIMATE CHANGE ADAPTATION AND RESILIENT FOOD SYSTEMS ISSUE

- Protecting soils from erosion and compaction, conserve/retain moisture and reduce production costs;
- Improving soil properties and the soil capacity to promote an increased biodiversity in the agro-ecosystem;
- Improving soil productivity while sustaining soil microorganisms and soil structure while also reducing the buildup of pests.

ESSENTIAL TECHNICAL INFORMATION

Conservation agriculture (CA) is a means to protect soils from erosion and compaction, conserve/retain moisture and reduce production costs. It comprises of the simultaneous application of the following three agronomic principles:

- **Minimal mechanical soil disturbance** (also referred to as minimum tillage, no-till farming, zero tillage, no-tillage, direct drilling, direct seeding). The practice is described under land preparation in section 5 above.
- **Maintenance of permanent soil cover with organic mulch:** Keeping the soil covered is a fundamental principle of conservation agriculture (CA) - alongside crop rotation and minimum soil tillage. Crop residues are left on the soil surface, but cover crops may be needed if the gap is too long between harvesting one crop and establishing the next. Cover crops improve the stability of the CA system, not only on the improvement of soil properties but also for their capacity to promote an increased biodiversity in the agro-ecosystem. While commercial crops have a market value, cover crops are mainly grown for their effect on soil fertility or as livestock fodder. In regions where smaller amounts of biomass are produced, such as the sorghum-based farming systems in semi-arid regions or areas of eroded and degraded soils, cover crops are beneficial as they:
  - ➔ Protect the soil during fallow periods.
  - ➔ Mobilize and recycle nutrients.
  - ➔ Improve the soil structure and break compacted layers and hard pans.
  - ➔ Permit a rotation in a monoculture.
  - ➔ Can be used to control weeds and pests.

  Cover crops are useful for:
  - ➔ Protecting the soil, when it does not have a crop.
  - ➔ Providing an additional source of organic matter to improve soil structure.

- ➔ Recycling nutrients (especially P2O5 and K2O) and mobilizing them in the soil profile in order to make them more readily available to the following crops.
- ➔ Provide "biological tillage" of the soil; the roots of some crops, especially cruciferous crops, like oil radish are pivotal and able to penetrate compacted or very dense layers, increasing water percolation capacity of the soil.
- ➔ Utilizing easily leached nutrients (especially N).

Different plants, with diverse rooting systems, explore different soil depths within the profile. They may also have the ability to absorb different quantities of nutrients and produce distinct root exudates (organic acids) resulting in benefits both for the soil and for the organisms. As different cover crops produce different amount of biomass, the density of the residues varies with different crops and thus the ability to increase water infiltration.

Vegetative cover is important in CA for the protection of the soil against the impacts of raindrops; to keep the soil shaded; and maintain the highest possible moisture content. In addition to nutrient recycling (outlined above) they also have a physical and, perhaps, an allelopathic effect on weeds, depressing their incidence and leading to a reduction in agrochemical use and thus in production costs

The presence of a mulch layer (of dead vegetation) in conservation agriculture inhibits the evaporation of soil moisture, yet leads to greater water infiltration into the soil profile. The percentage of rainwater that infiltrates the soil depends on the amount of soil cover provided. Straw residues function as a cushion that reduces the pressure on the soil under wheels and hooves and so they play an important role in reducing soil compaction.

- **Diversification into legume-based crop rotations or intercropping:** Growing the same crop year after year on the same land upsets the natural balance of soils. Too many of the same plant species in one field area rob the soil of its nutrients, resulting in decreasing varieties of bacteria and microorganisms that are needed to maintain fertility of the soil. One species of crop means that only one type of root will be available to trap moisture and prevent soil erosion. This work typically requires multiple types of roots. In monoculture, the root systems are not sufficient to maintain soil structure around the plants, leading to erosion and loss of water uptake.

  Including legumes in the cereal-based system through rotation or intercropping has been demonstrated to improve soil productivity through nitrogen fixation, additional carbon inputs, improve soil structure and by conserving nutrients. Crop rotation interrupts pest build up.

  The rotation of crops is not only necessary to offer a diverse "diet" to the soil microorganisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients. Nutrients that have been leached to deeper layers and that are no longer available for the commercial crop, can be "recycled" by the crops in rotation. This way the rotation crops function as biological pumps.

  Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of bacteria and fungi, which in turn, play an important role in the transformation of these

substances into plant available nutrients. Crop rotation also has an important phytosanitary function as it prevents the carry-over of crop-specific pests and diseases from one crop to the next.

The effects of crop rotation:

- Higher diversity in plant production and thus in human and livestock nutrition.
- Reduction and reduced risk of pest and weed infestations.
- Greater distribution of channels or biopores created by diverse roots (various forms, sizes and depths).
- Better distribution of water and nutrients through the soil profile.
- Exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species resulting in a greater use of the available nutrients and water.
- Increased nitrogen fixation through certain plant-soil biota symbionts and improved balance of N/P/K from both organic and mineral sources.
- Increased humus formation.

FACILITATING THE PRACTICING OF CONSERVATION AGRICULTURE

1.1. Minimum tillage

Land preparation for seeding or planting under no-tillage involves slashing or rolling the weeds, previous crop residues or cover crops; or spraying herbicides for weed control, and seeding/ planting directly through the mulch. Planting refers to the precise placing of large seeds (maize and beans for example); whereas seeding usually refers to a continuous flow of seed as in the case of small cereals (sorghum and millet for example). The planting/ seeding equipment penetrates the soil cover, opens a seeding slot and places the seed into that slot. The size of the seed slot and the associated movement of soil are kept at the absolute minimum possible. Ideally the seed slot is completely covered by mulch again after seeding and no loose soil should be visible on the surface

Crop residues are retained either completely or to a suitable amount to guarantee the complete soil cover, and fertilizer and amendments are either broadcast on the soil surface or applied during seeding.

1.2. Maintenance of soil organic cover

- In Burkina Faso the recommended cover crops are cowpea indeterminate type and groundnut for the targeted locales in Burkina Faso;
- In Tanzania the recommended cover crops are cowpea, green gram, groundnut and pigeonpea.

Cover crops are grown during fallow periods, between harvest and planting of the main crop hence utilizing the residual soil moisture or in alternative years. Their growth is interrupted either before the next crop is sown, or after sowing the next crop, but before competition between the two crops starts. Cover crops energize crop production, but they also present some challenges.

1.3. Crop Rotations

In general, design and implementation of crop rotations according to the various objectives: food and fodder production (grain, leaf, stalks); residue production; pest and weed control; nutrient uptake and biological subsurface mixing/cultivation, etc. Use of appropriate/ improved seeds for high yields as well as high residue production of above-ground and below-ground parts, given the soil and climate conditions.

In the drylands of Tanzania after growing adapted and released varieties of sorghum or pearl millet, this should be followed in the second year by groundnut, cowpea or green gram. Alternatively intercrop with pigeonpea where two-to-three rows of cereal are followed by one row of pigeonpea.

In Burkina Faso after cereals this should be followed in the second year by groundnut and cowpea.