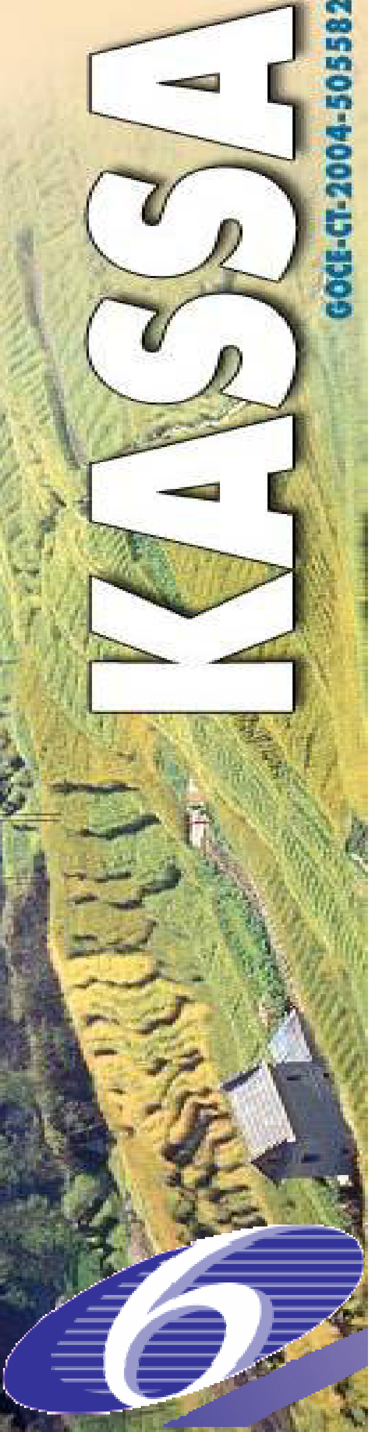

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CMU-SC Joint Meeting - Brussels, 9-10 January 2006

Workpackage 3

Validation of the

SYNTHESIS REPORT OF KASSA FINDINGS

Session III

KASSA Research Results:
Scientific knowledge acquired

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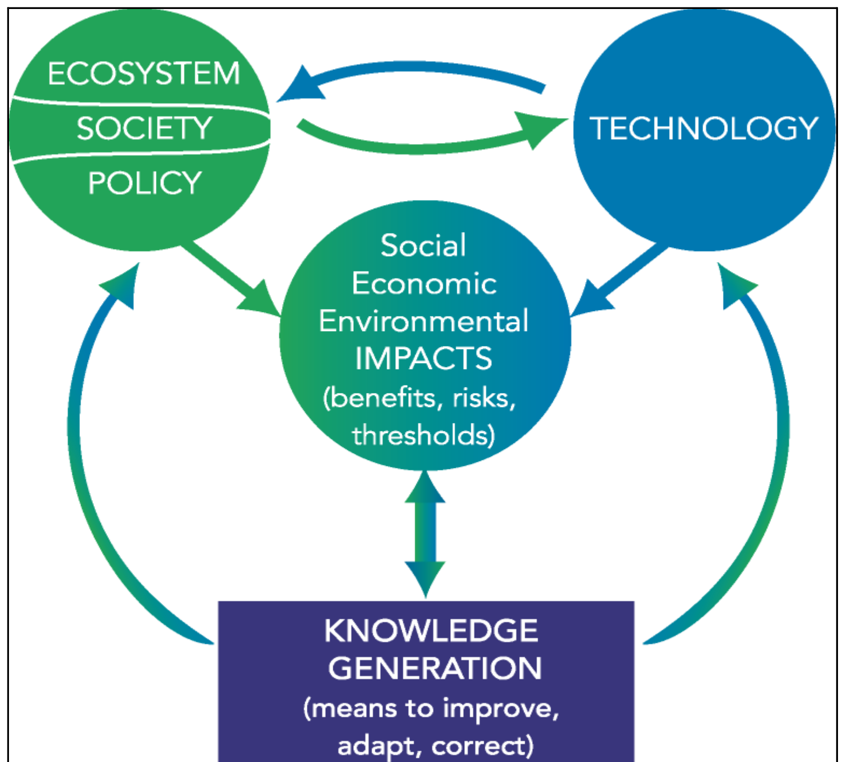
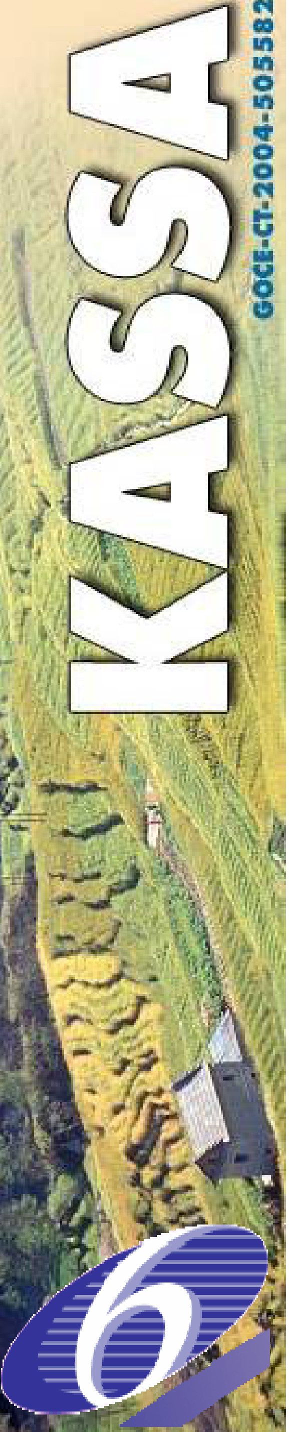
- How to foster more widespread adoption of Conservation Agriculture (**CA**) in agroecosystems of interest
- This section introduces the central theme of **impacts**

Fig. 1. The pillars of sustainability





What happens when widespread adoption of CA is achieved?

- Adoption
- Consequences for production costs, income and employment
- Consequences for resource quality (water, soil chemistry and nutrient cycling, soil biology, soil physics & water properties)
- Consequences for the environment: soil organic matter (SOM), soil carbon and GHGs; soil and water pollution, soil erosion

Adoption of CA

- Substantial in four agroecosystems:
  - Multiple multiple cropping on undulating lands under high rainfall in southern Brazil and Argentina
  - Crop-pasture systems in the Cerrados of Brazil
  - Wheat – soybean and related systems in lowland Bolivia
  - Rice-wheat and related systems in the Indo-Gangetic Plains

- Very large proportion of farmed land under CA practices in Latin America (**Table 12**):
    - Argentina: 60% of farmers (temperate, large scale)
    - Bolivia: 55% of farmers (subtropical, large scale)
    - Brazil: 75-80% of farmers (subtropical, large scale)
- Adoption of **zero till** wheat after rice in the Indo-Gangetic Plains (**Fig. 4**): > 2 m ha.
- Absence of CA adoption in lowland and upland agroecosystems in Vietnam.
- Levels of CA adoption in Mediterranean countries remains unclear.
- Little CA adoption in northern Europe (**Table 13**).
- Extent of **no-tillage** adoption worldwide (about **95 million ha** in 2004-2005) is given in Table 14.

Consequences of CA adoption for production costs, income and employment

<u>Production costs</u>

- **KASSA platforms teams provided data <u>only</u> for the following cost categories (most likely to be affected by CA adoption):**
    - Equipment costs
    - Labour costs
    - Input costs for weed and pest control
    - Soil fertility management costs
- **A more thorough analysis is needed, however, to assess costs and returns when crop rotations or mixtures are modified.**

- CA technologies reduce “costs in machinery and fuel and time-saving in the operations....” (Mediterranean platform).
- No-tillage “promotes a reduction of 46% in the total hours of equipment and machinery use...and similar reduction in the consumption of fuel and other lubricants” (Latin American platform).
- Estimates on fuel and labour costs savings using CA (reduced tillage and direct-seeding) were provided (Table 15) for Germany, Denmark and France (European platform).
- In the Indo-Gangetic Plains, no-tillage reduced fuel costs for wheat crop (by \$36-47 per ha in Pakistan and about \$50 per ha in India) and for pumping of irrigation water (Asian platform).

- However, above data underestimate machinery cost savings: information on cost categories of depreciation, interest and repairs was ignored.
- If CA machinery last longer than that for conventional agriculture, annual depreciation, interest and costs for repairs are lower: these are the data needed to get proper estimates of returns to farmer investment in new no-till implements.
- The transition to CA can also affect input costs.
- **What is the extent to which reductions in fuel and other machinery costs are offset by increased costs for herbicides, pesticides and fertilizers?**
- Different platforms teams provided different answers to this important question.

- If crop rotations are not used in CA the reliance on chemical use is higher (Latin American platform).
- Data from Germany (**Table 16**) indicate that cost savings from no-tillage are partly offset by increased herbicide costs (European platform).
- In contrast, “CA implies a reduction in the the cost of direct inputs” (Mediterranean platform).
- Adoption of wheat no-till after rice in the Indo-Gangetic Plains resulted in a decrease in herbicide use over time (**Fig. 5**) (Asian platform).
- Not clear whether new strategies for soil fertility management increase or reduce costs (Latin American platform).
- Cover crops: no extra cost in the Cerrados of Brazil, but not used in northern Europe due to their additional expense.
- The structure of farm-level production costs evolves over time (*transition period*).

Income

- Few references to effects of widespread adoption of CA on incomes.
- **Whose incomes?**
  - Poor urban consumers
  - The rural non-farm commercial and service sector
  - The rural landless poor and small-scale farmers
  - Farm families themselves
- **Improved profitability** depends on:
  - Higher yields
  - Output prices
  - Lower costs
  - Improvements in “enterprise selection” (decisions on crop or livestock enterprises)

What we have learned from KASSA platform reports on the effects of CA on crop yields and enterprise selection?

- In agroecosystems of southern Brazil (also in Cerrados), the introduction of **CA** had huge impacts on crop yields and enterprise selection ⇒ multiple cropping of annual crops has been possible ⇒ <u>higher farm family incomes</u>.

- In the Indo-Gangetic Plains, adoption of no-tillage in rice-wheat systems was driven by cost savings. No-till wheat yielded more than conventional till wheat due to:
  - more timely sowing
  - better stand establishment
  - no-till helped foster diversification (changes in enterprise selection) by increasing flexibility in sowing dates

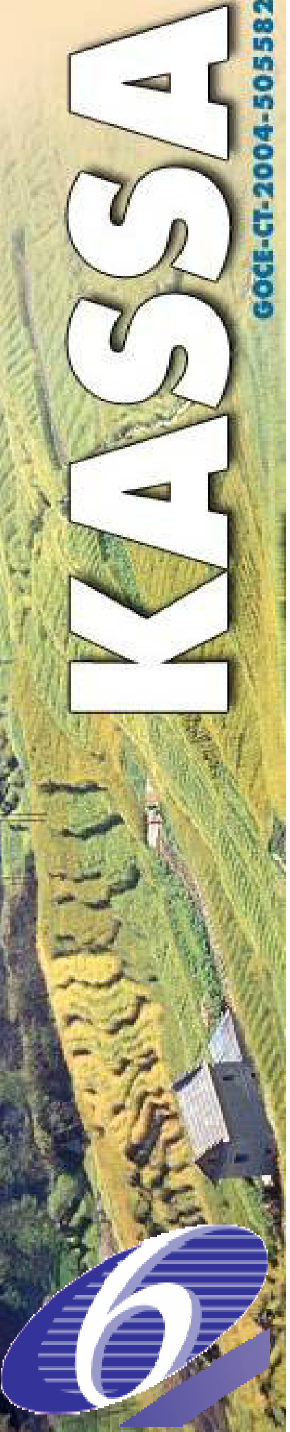
Employment

- The introduction of CA saves labour costs, but

Whose labour is “saved”? What alternative employment opportunities exist?

- For small-scale farms in southern Brazil, CA improved labour productivity and reduced labour requirements ⇒ incorporation of nonagricultural activities (e.g. home employees, hotel workers,...)
- In northern Europe,
  - alternative employment opportunities may favour CA adoption in large farms but
  - for many family farmers operating under marginal conditions they would have to supplement their incomes through finding local alternative ways of employment
  - agricultural employment represents only a small proportion of the total

- In the Indo-Gangetic Plains, the consequences of CA for employment are more sensitive:
    - For no-till wheat technology labor displacement is minimal because many small-scale farmers rent-in tillage and establishment services from service providers
    - In the eastern Plains, where animal traction tillage is more common, labor displacement may become more important
    - Two new CA technologies may have more dramatic consequences for employment:
        - **Direct-sown aerobic rice systems** ⇒ potential to displace rice transplanting labor (in the eastern plains performed by women and elsewhere by gangs of migrant laborers)
        - In contrast, **permanent bed and furrow systems with crop residue cover** ⇒ potential to generate additional employment and reduce irrigated water use by 30-40%, while improving yields



Consequences of CA adoption for soil and water resources

- **The biophysical processes are well known whereby CA technologies:**
  - increase SOM and biological activity
  - improve soil fertility
  - enhance soil stability
  - reduce soil compaction
  - conserve water resources
- **However, there is considerable variability across platforms and agroecosystems regarding the relative importance of different issues.**

Water resources and water productivity

- In many worldwide water-scarce environments, there are great expectations that CA can help enhance water productivity
- The **concept of water productivity** (product/water ratio):
  - Water productivity is defined as agricultural output per unit of water depleted
  - Crop (or livestock) water productivity is a measure of the ratio of crop (or livestock) outputs and services per unit volume of water depleted

What have been the impacts of CA technologies on KASSA agroecosystems where water productivity is a critical issue?

- Rainfed systems in the Mediterranean
- Irrigated systems in the Indo-Gangetic Plains

- **In the Mediterranean**, “CA in semiarid conditions reduces water loss from soil surface and enhances SOM accumulation ... increases water infiltration into the soil and improves water-use efficiency, especially in rainfed farming areas....”.
- Where CA has proved to reduce unproductive evaporation, or cut back on water pollution associated with soil erosion, then water productivity is increased.
- **In the Indo-Gangetic Plains**, issues affecting water productivity are more complex, including groundwater management, tubewell pumping and groundwater depletion, and drainage systems and salinization, among other issues.
- No-till wheat improves farm level water productivity by increasing yields while decreasing water depletion.
- Stronger improvements in water productivity can be obtained from the use of ridge and furrow systems in the production of lowland rice and virtually any upland crop.

Soil chemistry, biology, physics and nutrient cycling

- Assessing CA effects on soil properties is difficult due to the strong interactions among soil chemical, biological and physical properties and processes.
- Most platforms mentioned beneficial effects of crop residues and other sources of soil cover on **SOM and soil fertility**.
- However, there are areas in cooler climates (e.g. Nordic areas) where organic matter fluxes are so very slow that no-tillage can actually cause problems (additional manipulation to increase decomposition intensity).
- No-tillage improves biological N fixation and increases microbial biomass carbon (Latin American platform).
- CA and no-tillage effects on SOM and soil chemistry concentrate near the soil surface – vertical gradient (European platform) – stratification – more favourable environment on the first mm and cm (Latin American platform).

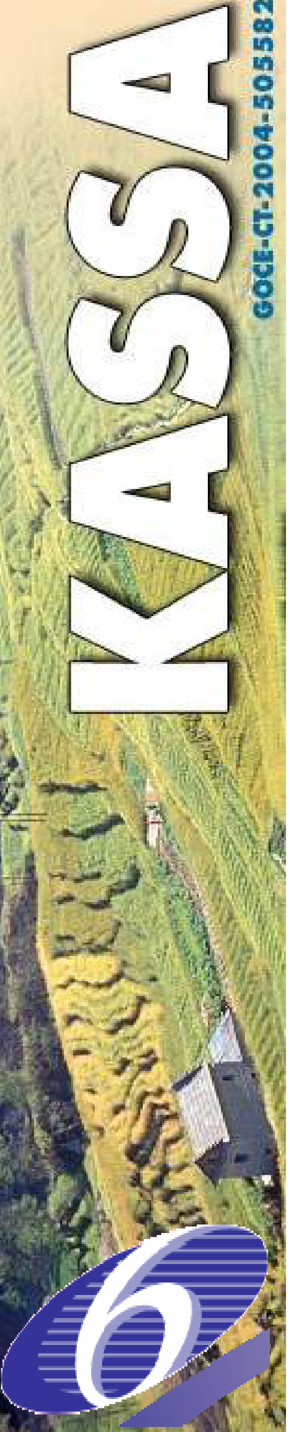
- No-tillage increases soil flora and fauna.
  - Increase in abundance and biomass of eartworms when tillage intensity is reduced (Asia and European platforms)
- With regard to soil structure and soil physics:
  - Main issue: compaction in light textured soils under no-tillage (European platform).
  - Reduced tillage (chiselling) has not been a solution to the compaction problem (Latin American platform).
  - In Asia, problems of soil structure and compaction driven by soil puddling for lowland rice cultivation $\Rightarrow$ limits residue retention and use of cover crops within crop rotations.
  - The platform teams called for the development of soil maps, databases and decision support systems to help match CA practices to soil and water conditions.

Consequences of CA adoption for the environment

- Potential of CA practices to reduce soil erosion, soil and water pollution and greenhouse gas emissions.

Soil erosion

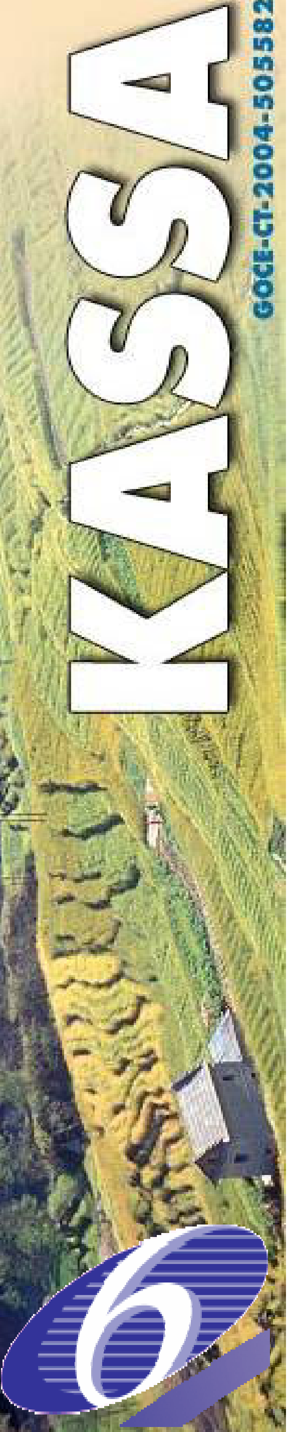
- Water erosion most serious in southern Brazil and sloping lands of northern Vietnam.
- Water and wind erosion also a problem in Mediterranean agroecosystems and in northern Europe.
- In southern Brazil: use of soil cover to control erosion. However, CA concentrates nutrients near the soil surface $\Rightarrow$ potential high rates of nutrient losses due to intensive rainfall events.
- In Argentina: no-tillage + complementary soil conservation techniques, such as contour planting, strip cropping, ...).



- In Vietnam: soil cover (+ mulching) effective in controlling erosion (**Table 17**).
- In Mediterranean rainfed ecosystems (e.g. in semiarid cereal/fallow areas), reduced tillage (chiselling) can help control wind erosion.
- In northern Europe, results from experimental stations indicate that no-tillage results in reduced water erosion during both the cropping period and the intercrop.
- Reduced water run-off during the intercrop only occurs when a cover crop is used.
- On-farm results confirm this effect that tends to increase and become stronger over time.

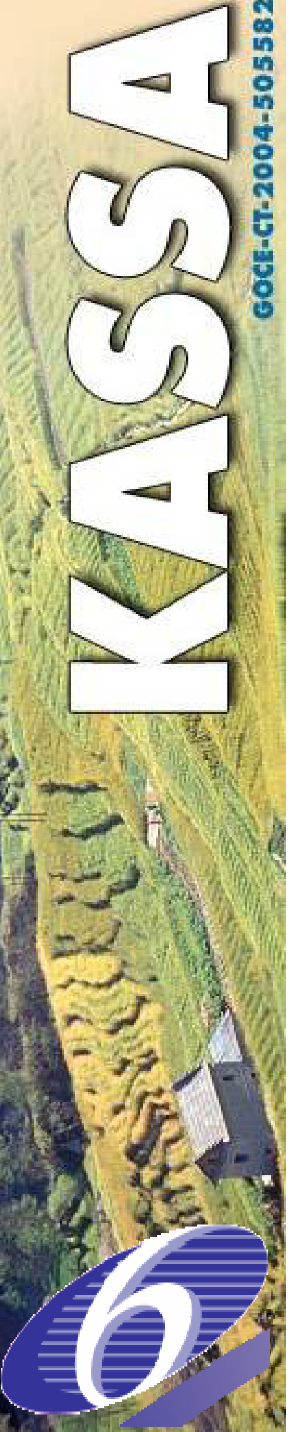
Carbon and greenhouse gases

- The relationships between CA and carbon sequestration and greenhouse gas (GHG) emissions is an important but controversial topic.
- GHG emissions (CO_2, N_2O, CH_4) from soils can be combined into a single “carbon equivalent” measure.
- The Asia platform mentioned a large reduction in the use of fuel (reduction in C equivalent emissions) by tractors and pumps atributable to a shift to no-tillage.
- It would be useful to obtain better estimates of C savings from “fuel not burned” for more KASSA ecosystems.
- CA leads to an increase in soil organic carbon (SOC) levels. Details are provided for locations in Brazil (**Table 18**).
- Some information was gathered by KASSA teams on GHG emissions from soils.



Soil and water pollution

- Almost all the information on the relationship between CA and pollution comes from the European and Latin American platforms reviews.
- Lists of highlights from platform reports on findings regarding the following issues of concern:
  - Levels of herbicide use
  - Speed of herbicide breakdown and sorption on organic matter
  - Nutrient leaching into groundwater
  - Heavy metals
- Soil and water pollution in the context of CA deserves more investigations in the future.
- Better indicators and decision support tools are needed for more sensible assessment of food-chain and public health risks.



THANK YOU FOR YOUR ATTENTION