

ACN FICHE TECHNIQUE

ACN Water Harvesting Technology Module

“Aménagement en courbes de niveau” (ACN): a water harvesting technology to increase rainfall capture, water storage and deep drainage in soils of the Sahel



USAID
FROM THE AMERICAN PEOPLE

July 2008

ACN FICHE TECHNIQUE

ACN Water Harvesting Technology Module

“Aménagement en courbes de niveau” (ACN): a water harvesting technology to increase rainfall capture, water storage and deep drainage in soils of the Sahel

Richard Kablan

Department of Tropical Plant and Soil Science, University of Hawaii, USA

Russell S. Yost

Department of Tropical Plant and Soil Science, University of Hawaii, USA

Kevin Brannan

Biological Systems Engineering, Virginia Polytechnic and State University, USA

Institut d’Economie Rurale (IER), Mali

Mamadou D. Doumbia

Kalifa Traoré

Abdramane Yoroté

Youssouf Toloba

Salif Sissoko

Oumar Samaké

Michel Vaksman

Lasana Dioni

Mankan Sissoko



July 2008

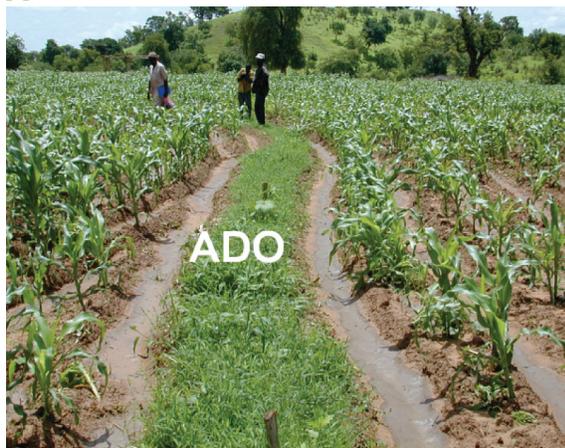
This brochure was made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the Soil Management CRSP (Grant No. LAG-G-00-97-00002-00) of the University of Hawaii and do not necessarily reflect the views of the USAID or the United States Government.

OVERVIEW

The Aménagement en courbes de niveau (ACN) is a holistic landscape approach to manage water and capture rainfall on a watershed scale (Gigou *et al.*, 2006). It is a technology developed locally by the Institut d'Economie Rurale (IER) and CIRAD (Gigou *et al.*, 2006).

The permanent ridges (Ados) (Figure 1A), about 100 cm wide, are constructed on the contour once and maintained in subsequent years. The smaller ridges are constructed following the contour indicated by the permanent ridge. Various other structures may be required annually (in Mali) (Figure 1B) depending on the “Diagnostic” assessment of a technician and the farmer.

A



B



Figure 1. Structure of an ACN in a field showing Ado (permanent ridge) (A) and annually drawn ridges (B).

OBJECTIVES

ACN as a Tool to Increase Rainfall Capture, Storage and Drainage in Soils

The principal objective of the ACN technology is to retain or capture rainfall on the field, which helps to overcome the typically low infiltration rate of the soils (Kablan *et al.*, 2008). This retention of water reduces destructive runoff and enables multiple uses of the captured rainfall. As a result of the increased infiltration of rainfall, water availability increases improving crop growth and reducing erosive runoff as shown in long-term studies initiated by Gigou *et al.* (1997, 1999 and 2006) and soil water storage studies (Kablan *et al.*, 2008). These findings document increased soil water content resulting in increase crop yields. Yields may increase as much as 50 percent for millet, sorghum, and maize (Gigou 1996 and Gigou *et al.*, 2006); as well as increase in tree growth of associated within the traditional parkland cropping systems.

ACN as a Technology to Increase C Sequestration in Soils

The hypothesis that ACN may lead to an increase in soil organic carbon has been substantiated in Mali, Sénégal and the Gambia (Doumbia *et al.*, personal communication, 2008).

The implementation of ACN increases C sequestration in soils by several mechanisms:

1. Increases soil moisture capture;
2. Reduces soil losses through runoff;
3. Retains nutrients from other sources including nutrients from the soil itself;
4. Increases above and below biomass growth of crops and tree plants associated with ACN; and
5. Increases infiltration.

The increased infiltration replenished water stocks in the subsoil and increased the growth of existing trees (*Vitellaria paradoxa* and other valued species) in the traditional cultivated tree parks. The increased soil moisture facilitates the germination of seeds from trees and establishment of seedlings. The ligneous bio-mass is therefore increased, contributing to carbon sequestration.

Overall ACN increases cereal yields and carbon stocks in the soil, and thus promotes more sustainable small scale farming in semi-arid Western Africa.

LOCATION AND ADVANTAGE

The ACN technology is used in Mali, Senegal, The Gambia and Cameroon in regions with high susceptibility to erosion due to low infiltration rate and high intensity of rainfall during the short rainy season. ACN is also suitable in regions with evidence of wide-spread of severe erosion with slopes of 5 percent or less (Doumbia Mamadou 2006, personal communication).

Contoured ridges can increase infiltration of rain water by up to 10 per cent of the total annual rainfall, even in fields with a gentle slope between 1 to 2 per cent (Traoré *et al.*, 2004). The increased rates of water infiltration with ACN suggest that the reduction in surface runoff of rainwater results in greater capture and deeper percolation of water into the soil. Reduced runoff and greater infiltration have several implications: 1) soil surface erosion and downstream flooding are reduced; 2) deep-rooted crops such as tree species (i.e., *Vitellaria paradoxa*) and shrubs (*Piliostigma reticulata*) are able to take advantage of the extra reserve of soil moisture with depth; and 3) farmers and village residents report that drinking water supplies and water for irrigation in the off-season are in greater supply and more available than before (Siguidolo villagers, 2006, personal communication).

Furthermore, the ACN technology may allow earlier planting of the more photoperiod-sensitive local cultivars of sorghum and millet resulting in increased biomass and grain yields.

Additionally, increased biomass of trees associated with ACN farming contributes to improved conditions for carbon sequestration.

EQUIPMENT AND RESOURCES

The equipment and resources necessary to implement the ACN technology include 1) a field technician (“Amenagist”) with an auto level, a metered rod and some 30-50 stakes depending on field size; and 2) the farmer or group of farmers with an ox-drawn plow preferably or hoe.

The implementation of the ACN technology can be an expensive and time-consuming work for farmers with-

out the proper equipment. Know-how on how to construct the ridges is necessary for the ACN system to function properly. A well designed maintenance program is also required. It is highly recommended that introducing a farmer to the system must proceed in steps with only part of the field implemented at a time, allowing the farmer to learn the new system.

HOW THE ACN TECHNOLOGY IS USED

Placing a field under ACN management involves three steps:

1. A survey of the land and a diagnosis of water flow problems of the particular field, jointly carried out by the soil and water conservation technician and the farmer for the purpose of developing a general plan of water management (“Diagnostic”);
2. Staking the locations of the permanent ridges on the contour (Ados) by the field technician using a level (“Piquetage”);
3. Construction of the Ados (permanent ridges) by the farmer using an ox-drawn plow, or hoes if plows are not available.

Usually five or six passes by the plow are sufficient for the initial ridges, but careful maintenance is required by the farmer, especially during the first rainy season before the Ados are stabilized. The annual small ridges can be constructed along the major ridges depending on cropping systems. Waterways to evacuate excess water from fields may also be constructed as part of the ACN system depending on the specific requirements or hydrologic conditions of the field. Usually, the Ados stabilize after the first year, with minimal but critical maintenance needed subsequently.

A typical distance between the permanent ridges (Ados) ranges from 20 to 50 meters with distance between Ados decreasing with increasing slope. If the slope is very flat, the maximum distance between the Ados will be 50 m. If the slope is steep, the Ados will be placed such that change in elevation between the Ados never exceeds 80 cm (Figure 2).

IMPLEMENTATION PROTOCOL

Diagnostic

The process of carrying out the “Diagnostic” is usually the first step in the ACN process. It is carried out jointly by the farmer or land manager and the ACN technician. The farmer and the ACN technician walk and survey the field or fields to be placed under ACN technology with

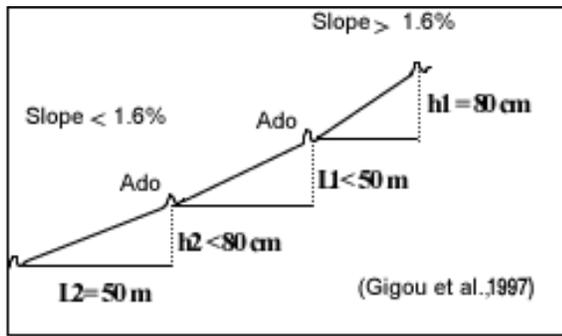


Figure 2. Distance between Ados based on land slope (after Gigou et al., 1997).

the objectives of assessing major water issues, problems, and challenges in the field, such as:

- Run-on or rainfall runoff from neighboring fields onto the field. This may require soil bunds or evacuation channels to divert the water.
- Ravines within the fields – will require waterways to properly dispose of excess water.
- Low portions of the field as well as high portions could cause unusual needs in management.
- Extreme slope in certain portions of the field – may require the installation of rock bunds (“cordon pierreux”).
- Assess the farmer’s capability and resources to carry out the ACN construction and maintenance.
- A labor requirement – to draw the permanent ridges at the beginning of the rainy season requires assistance. A set of bullocks and a plow will be needed to draw the Ados (see Figure 8). Unfortunately, this occurs at the beginning of the rainy season when there is also concern to quickly prepare the soil and plant the subsistence crop – often millet in Mali. Usually the time required is minimal, however, as several hectares of ACN can be prepared per day.
- Problems identified during the diagnostic must be dealt with. For example, run-on is prevented by constructing soil bunds or diversion channels (Figure 3).



Figure 3. Diversion channel.

Layout – Piquetage (Staking)

This starts the process of locating the Ados (permanent ridges) on the farmers’ field with a walk over the entire field (Figures 4 A&B).



Figure 4. Initial field survey with farmer and ACN technicians (A) as critical water issues are discussed and solutions are compared and recommended (B).

Two initial transects are taken in the approximate extremes of the field at a right angles to each other (Figure 5). These transects give the general slope of the field and help locate the high spot of the field. The

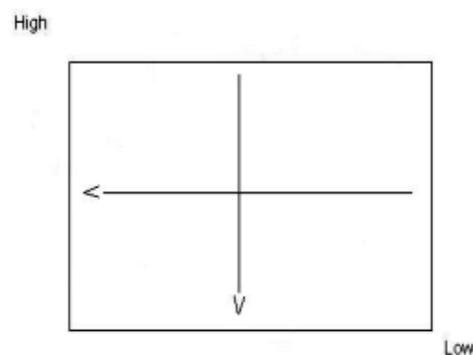
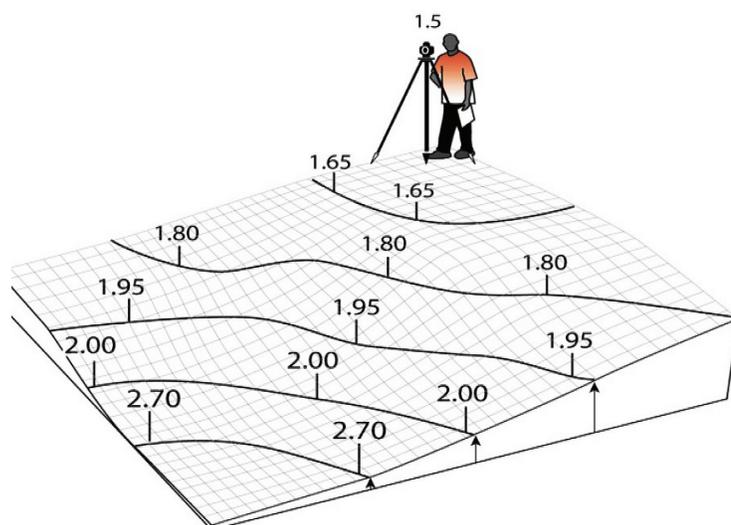


Figure 5. Field transect showing high and low spots of the field.

high spot will be the beginning location of the first Ado.

Once the highest spot in the field is found, the first stake of the Ado line is placed at that point. Successive stakes are laid out descending across the field at a slope of 80 cm maximum decline or 50 meters in distance, whichever occurs first (Figures 6 A & B).

Distances between stakes are kept at a maximum of 10 meters (Figure 7). The laying out of the Ados is completed when the entire field has been covered (Figure 7).



A



B



Figure 6. A field technician laying out Ados in a farmer's field (A) with a slope decline of 80 cm or 50 m in the distance (B).

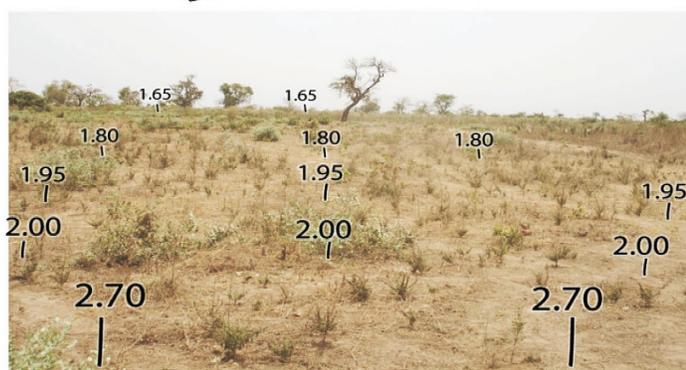


Figure 7. A completed staked farm field showing Ados locations.

tions include constructing them by hand with various tools such as hoes or shovels.

Figure 9A shows a schematic field with completely constructed Ados. Figure 9B shows a fully functional Ados with annually drawn ridges in a farmer's field.

Maintaining the Ados

Maintenance of the Ados and the ACN in general is important and must be carried out periodically, both

Drawing the Ados

Constructing the Ados usually takes place at the beginning of the rainy season, because that is the only time that the soil can be plowed without damaging plowing equipment. This is a challenging period for ACN implementation because this also is the time of intense field activity and constructing the Ados competes with other operations. Ados are commonly constructed with a mold board plow (Figure 8). Usually only four to six passes are needed to form Ado of nearly a meter in width and some 20 to 30 cm in height. Other op-



Figure 8. Constructing an Ados.

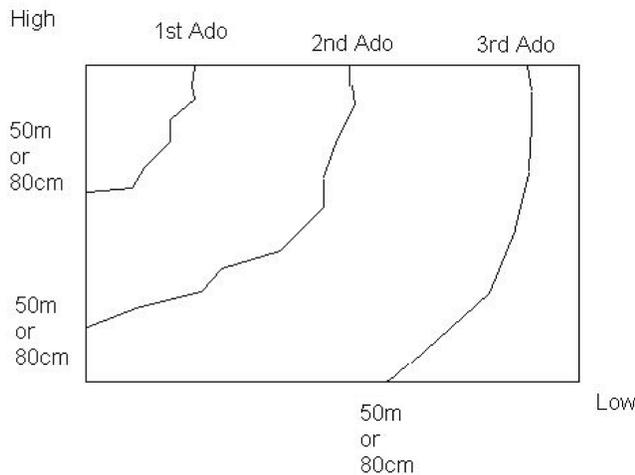


Figure 9A. Schematic farm field with three Ados lines.



Figure 9b. Functional Ados and annual ridges in a farmer's field.

because the Ados may need reinforcement to ensure integrity and performance in capturing rainfall and assisting in channeling excess water of the field. Often during the first year, the Ados will need reinforcement, especially if there are intense storms, typical of the region. Many soils of the Sahel are sandy and develop hard crusts. The Ados will often become quite solid after just one year.

Depending on management, however, the Ados' integrity may not be maintained and they may become too flat (Figure 10).

In such cases the land manager needs to reconstruct the Ados or the Ados and the ACN technology will no longer function.

In other cases, there may be new sources of run-on or new hydrologic issues that develop in the field. In



Figure 10. An "Ado" that needs rebuilding -- it has become flattened and is virtually useless.

such cases the entire plan for managing water on the field needs to be reviewed and re-evaluated for its suitability to current conditions.

Results from soil moisture data obtained at Siguidolo (Kablan *et al.*, 2008) have shown that the ACN affects many aspects of the water cycle. This study revealed that the soil horizon at 20–40 cm depth was probably near field capacity. Further, soil water contents even exceeded field capacity at 30cm depth in the ACN plots early in the cropping season. In contrast, the No ACN treatment did not exhibit any increased moisture in the 20–40 cm horizon. Compared with the remainder of the soil profile, the 20–40 cm horizon held most of the soil moisture in July during the early stage of the rainy season. The higher clay content of the 20-40 cm horizon notably retained more water throughout the season and even into the post season.

Overall yield increase has been reported in Mali, Senegal and the Gambia wherever the ACN technology has been implemented, especially during drier years when crop yields can be increased by as much as 50 percent for millet, sorghum, and maize (Gigou, 1996; Gigou *et al.*, 2006) over crops planted using traditional practices.

ADDITIONAL ACN BENEFITS

Mali

Farmers and village residents report more water in drinking water wells than earlier (Siguidolo villagers, 2006, personal communication). This increase ground water replenishment has enabled off season irrigation of women's home gardens and spontaneous regeneration of useful trees.

The Gambia

Substantial increases in population and growth of shrubby species trees (*Icacina senegalensis*) and plowing the shrubby species under, prior to planting maize, has led to substantial increase in organic soil carbon content in ACN plots.

Sénégal

In Sénégal, ACN increases peanut yield and soil carbon content in the peanut basin of Sénégal (Sudano-Sahelian). Soil moisture profile measurements, using a neutron probe, clearly indicate that early in the growing season ACN promotes a rapid downward movement of the wetting front and permits greater topsoil water content right after a rainfall event. As a result, runoff is reduced. ACN also positively affects peanut crops maturation date.

Overall, positive effects on total biomass and grain yield were observed for peanut and sorghum crops. The improved biomass production increases available crop residue, and thus potentially an increased soil carbon content.

REFERENCES

- Kablan, R., R.S. Yost, K. Brannan, M.D. Doumbia, K. Traoré, A. Yoroté, Y. Toloba, S. Sissoko, O. Samaké, M. Vaksman, L. Dioni, L. and M. Sissoko. 2008. "Aménagement en courbes de niveau," Increasing Rainfall Capture, Storage, and Drainage in Soils of Mali, Arid Land Research and Management, 22:1, 62 – 80.
- American Society of Agricultural and Biological Engineers (ASABE). 2006. Design, layout, construction and maintenance of terrace systems. American Society of Agricultural and Biological Engineers, St. Joseph, MI.
- Gigou, J., K. Traoré, F. Giraudy, H. Coulibaly, B. Sogoba, and M. Doumbia. 2006. Aménagement paysan des terres et réduction du ruissellement dans les savanes africaines. *In* *Agricultures* (2006) vol. 15: no. 1, p. 116–122.
- Traoré, K.B., J.S. Gigou, B.H. Coulibaly and M.D. Doumbia. 2004. Contoured ridge tillage increases cereal yields and carbon sequestration. ISCO 2004 - 13th International Soil Conservation Organization Conference – Brisbane, July 2004; *Conserving Soil and Water for Society: Sharing Solutions*.
- Gigou, J. 1996. Méthode d'aménagement en courbes de niveau à l'échelle du champ. *In* A. Ratnadass, J. Chantereau, and J. Gigou (eds). *Amélioration du sorgho et de sa culture en Afrique de l'Ouest et du Centre. Actes de l'atelier de restitution du programme conjoint 4 sur le sorgho Icrisat-Cirad*. 1997=3=17–20. Bamako, Mali. Collection colloques, Montpellier, Cirad-ca.

For further information, please contact:

Dr. Mamadou Doumbia, Chef de Laboratoire
Institut D'Economie Rurale (IER)
B.P. 262, Bamako, Mali
M: 223-673-9628

Dr. Abou Berthé, Chef de Équipe, ESPGRN
Institut D'Economie Rurale (IER)
B.P. 262, Bamako, Mali
M: 223-646- 3574

Dr. Richard A. Kablan
Department of Tropical Plant and Soil Sciences
University of Hawaii at Manoa
3190 Maile Way
Honolulu, Hawaii 96822 USA
T: +808-956-6883
F: +808-956-2711
E: rak@hawaii.edu
Web: <http://tpss.hawaii.edu/sm-crsp>

Dr. Russell Yost, Principal Investigator
SM CRSP
Department of Tropical Plant and Soil Sciences
University of Hawaii at Manoa
3190 Maile Way, St. John 102
Honolulu, HI 96822
T: 808-956-7066
E: rsyost@hawaii.edu

