Myths in Land Degradation and Development

Farewell address upon retirement, May 3 2012

Prof. dr *ir* Leo Stroosnijder

Dear audience,

After being employed for over 45 years at Wageningen University, I consider it an honor to address my farewell speech to you. What kept me inspired these many years is the combination of research and capacity building, which is so typical for a University. In addition, I have always been attracted to development cooperation. I tried to bring newly developed knowledge into courses and study programs with a special focus on the tropics. Of course this also meant that I found special satisfaction in working with foreign PhD students.

What can you expect in this 45 minute farewell address? First, a brief overview of the various types of capacity building I have been involved in, and an explanation of my current science field: Land Degradation and Development, (abbreviated hereafter as LDD). And then I'll summarize some of the findings of more than 50 PhD's in LDD. The focus will be on a number of myths that they helped to unmask.

My capacity building career started in 1965. Just after turning 18, I became a student-assistant at the physics practical at Duivendaal, here in Wageningen. In 1970 I got a job as a soil physicist under prof. Bolt. I improved the soil physics practical and started tutorials for Bolt's lectures, which were perceived by the students as too difficult.

After a period of 4 years in Mali (West Africa) for an interdisciplinary research project under Cees de Wit (Penning DeVries and Djitèyè, 1982), I became director of a follow-up project where, together with Nico de Ridder, we disseminated our research findings with lecture notes and field excursions in English and French (DeRidder et al., 1981). In 1987 we got the Dutch Award on Environment & Development for both projects.

In 1985, I started an MSc program in Soil & Water at the Brawijaya University in Malang (East Java) which actually was a copy of Wageningen's first international MSc program. I lived in Indonesia for 4 years and many Dutch students profited from that outreach post, where we also started another interdisciplinary research project called INRES; several PhD's obtained their degree during this project, for instance Stella Efde and Teunis van Rheenen (Stroosnijder, 1989).

From 1990 onwards, I was director of the Wageningen outreach post 'Antenne Sahelienne' in Ouagadougou (Burkina Faso) for 10 years (Stroosnijder and VanRheenen, 2001). About 300 students - from Wageningen and many other universities - did their thesis work there, and a number of them got their PhD cum laude.

In addition, many missions were made for NUFFIC's capacity building programs in Eritrea, Mozambique, The Philippines, Ethiopia, Rwanda and Uganda. All this experience was used in a 4 year term as a board member of the Wageningen Educational Institute, the OWI as we call it. And for 20 years, I taught the introductory course in Soil & Water Conservation which was awarded education quality bonuses several times.

This brings me to the science field of Land Degradation and Development. In 1990 I started as professor in a new chair group called 'Land and Water Management in rainfed agriculture, with special focus on the semi-arid tropics' for which a lot of new lectures and practicals were developed (Stroosnijder, 1990; Stroosnijder and Eppink, 1990). At that time the focus was still on the tropics and teaching was done through the study program '*Tropische Cultuurtechniek*' (Tropical land and water management). Because Wageningen University was previously an Engineering University, we were looking for practical applied solutions to combat current erosion. At that time we thought that human-induced erosion posed the biggest threat to food security. Erosion can be mitigated with Soil & Water Conservation measures. Hence the field of science field was renamed 'Erosion and SWC' since, for quite a while, we were no longer focused on the tropics alone.

The dominant stakeholder in SWC is the farmer who has to apply the conservation measures to her or his field. This is why the field covers both technical as well as socio-economic aspects and the interdisciplinary playing field is a triangle with MODELS, MEASURES and MAN in the corners as shown in Figure 1.

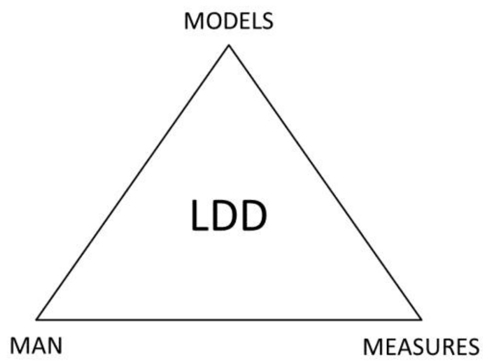

Figure 1 Triangular playing field of the Land Degradation and Development (LDD) Group of Wageningen University. 'MODELS' stands for: processes, models and measurements. 'MEASURES' stands for: assessment, design and watershed management. 'MAN' stands for: impact, adaption and policies.

A couple of years ago we renamed our field of science again, this time to Land Degradation and Development. Why? Firstly because, besides erosion, more forms of land degradation are nowadays considered important. Second, because the focus on soil was too narrow while the term 'land' refers to natural resources as a whole and it is - that is the soil with its natural water, flora and fauna. It is the land and not the soil alone that provides our food and the livelihood for millions of small farmers. But even more important was that many land changes that are considered by many to be 'degradation' are in fact signs of 'land development', needed in a changing world. So, the word 'development' was purposely intended to have a double meaning, development of land as well as development in the economic sense.

With my retirement LDD will disappear. Not really of course – just in name. It will now merge with another Group in Wageningen and continue under the new name 'Soil Physics and Land Management'.

Part 1 MAN

I imagine that you are now anxious to hear about the myths. You remember LDD's playing field with MODELS, MEASURES and MAN in the corners? Ok, I will start with myths related to 'MAN'. 'MAN', in this case, stands for the millions of small scale farmers in developing countries, many of them women (VanKoppen, 1998).

The first myth is that:

Farmers are economically irrational

and lack market orientation

Let me explain (using some of the findings of LDD PhDs) why I call this a myth. Food production in Africa is in the hands of millions of small scale farmers, many of them illiterate. But, at the same time they are rational entrepreneurs, acting strategically and adapting on the basis of experimentation with flexible resources of land, cash and labour (Mazzucato and Niemeijer, 2000; Traore, 2006). Their economic considerations have far more impact than the perceived social constraints. This is why there is an Agricultural Economist in the LDD staff and not an Agricultural Sociologist.

But what is 'their economy'? From LDD's fieldwork, it became evident a long-time ago, that the neo-classical economy based on free market, rational decisions and profit maximizing is not useful in developing countries. Markets are imperfect and both producers and consumers act in ways that are irrational, at least according to the neo-classical definition.

In 1995 this insight was postulated as 'The Agricultural Economy' (De Graaff, 1996; Ehrenstein, 1999). Major findings relevant for the LDD domain were: (1) Benefits and costs of LDD are extremely difficult to measure and quantify, and are scale dependent; (2) farmers only adopt conservation measures if the Benefit/Cost ratio is above 2 and (3) interventions in developing countries are subject to high transaction costs which are mostly ignored by planners and policy makers (Bodnar, 2005). In other words, you need an agricultural perspective to understand why farmers are adopting conservation measures or not.

Subsequent research in the economics of LDD resulted, in 2000, in the grounded theory of the Cultural Economy (Mazzucato and Niemeijer, 2000). This theory is a mixture of market and social institutions, best illustrated with the following example. Farmers in Burkina Faso have few activities to do in the dry season. There is no rain, the soil is dry and very hard and there is little alternative employment. In spite of an apparent excess of spare time, farmers are not eager to invest this time in conservation measures that aim at improving food security when rains fall short. Instead, they travel for weeks and weeks to relatives as far as 100 km away. Why? Because, when a real drought strikes their village, the conservation measures will not help enough. Instead, food may be obtained from relatives in neighboring villages. Drought is often very local and may not affect villages 20 km away. In other words, networking is a better food security strategy than soil and water conservation. That is what the 'cultural economy' is about.

Conclusions from this cum laude work in 2000 shaped LDD teaching and research. A major finding was that land degradation is far less serious than thought and often confused with land development. So, I agree with Folmer (2012) who recently argued that 'Western style' economic science has lost credit because it lost the link with history, sociology and psychology. I also think it concentrated too much on models. The ever increasing complexity of models falsely suggests a sense of reality. I will give you a striking example later on. In my opinion, newer forms of economic science like institutional and behavioural economics are better for explaining the adoption or non-adoption of improved land management in developing countries. So this is what the LDD Group focusses on.

Now my comments on the market. It is often argued that farmers lack market orientation. But it is not so much a lack of orientation, it's really limited access to markets (Bidogeza, 2011). Subsistence farmers everywhere are entering the market by intensifying their production systems (Posthumus, 2005). This implies that they need credit (like all intensifying farmers in the world) but that is not easily available in an emerging economy and is subject to large scale extortion. Take Benin as an example: the majority of the farmers borrow against an interest rate of > 100%. All the excess they harvest above subsistence level, goes into debt payment. So, even among small scale farmers there is a debt crisis - they live on borrowed money similar to what we do in the rest of the world.

The way forward is to solve this debt crisis and link farmers with small business. The theory of 'the bottom of the pyramid' (Prahalad and Hart, 2004) is a step in the right direction and we are investigating its effect in Benin (Mazu, 2013). Though I do not believe in social constraints, I think that the right institutions (local, national and international rules of the game) are instrumental in a thriving economy; we all understand that dumping excess EU food in Africa frustrates local agricultural producers. Lack of food security is neither a technical problem nor a degradation problem. It is the lack of proper institutions, lack of enforcement of existing rules of the game, and mistrust among communities due to corruption. So, better 'governance' is a good idea here (Kessler, 2006).

Another myth related to 'MAN' is that:

Sustainable development is only possible

with full participation of farmers

Participatory approaches in the development arena are still popular. LDD has always worked with farmers (Tenge, 2005). We have asked them many questions, but it is our experience that their answers must be considered with great care. In many cases farmers give the answers which they assume that the interviewer wants to hear, or an answer that provides some benefits for the farmer. The only way to get insight into what farmers do and why is to obtain trust. This takes time; two PhD students lived for a full year in a village before they asked their first content question. In general, research with farmers in developing countries should be done by local researchers, not by us westerners.

Participation of farmers and other stakeholders is indeed important for identifying problems, technical solutions and new rules of the game (Nabahungu, 2012; Mutekanga, 2012). But that's easier said than done: the gap between a poor illiterate farmer and the other stakeholders is often too large. Fortunately Role Playing Games and Serious Gaming (Schoolenberg, 2012; www.weirdbeard.nl/dev/highlandfarmer) are promising new tools to bridge this gap.

Participatory approaches are often based on the idea that 'the farmer pays'. However, small scale farmers in developing countries are seldom able or willing to do that. How can we think that this would work? Have a look at The Netherlands: the farming infrastructure is the result of many rounds of '*ruilverkaveling*' (allotments and re-allotments) for which a lot of public money was used. Realistic mitigation of land degradation needs public investment. And this has, in my opinion, consequences for the participatory process. In The Netherlands, with a focus on the environment, we often use the saying 'the polluter pays'. Mitigation of land degradation will only be realistic if we accept that 'the payer determines'. In other words, public money is needed but public concerns then also co-determine what measures should be taken: this is the cross-compliance idea widely used by the EU.

In conclusion: Full participation, with the mitigation bill in the farmers' lap will not work (Zenebe Adimassu, 2012). Participation is a must in the initial stages. But, once there is agreement on a development path and public money is involved the new rules of the game should be enforced to mitigate mistrust and corruption.

Part 2 MEASURES

And now, ladies and gentlemen, some myths related to the MEASURES that can be taken to mitigate land degradation. MEASURES only make sense if there is in fact land degradation. And this brings me to the myth that:

Land degradation threatens global food security

This is the so-called doom myth. Of course there is local land degradation but I do not believe in a doom scenario that land degradation is so common, serious and wide spread that it endangers our world. Famous in doom thinking (but nowadays unmasked) is a publication by 11 scientists in Science in 1995 (Pimentel et al., 1995; Pimentel, 2006). This article refers to productivity losses in the order of 8% per year which would lead to production today being only 20% of what it was when the paper was written. A similar unrealistic outcome is obtained with the doom scenario on soil fertility that was published (with worldwide references) by Stoorvogel and Smaling (1990). Even more recently the world Food and Agriculture Organization (2011) stated that 'urgent steps need to be taken'. Unfortunately at the FAO, which steps need to be taken always depends on the current hype in Food Science and Policy. Nowadays these hypes are 'improved governance of land and water resources' and 'institutional and policy changes'.

LDD findings go against the main stream of international organisations like FAO, but also against NGO's and many other institutions that obtain their legacy from the land degradation paradigm. We found no evidence of widely claimed soil degradation in East Burkina Faso (Mazzucato and Niemeijer, 2001). Erosion rates in the Mediterranean are often exaggerated because of inappropriate extrapolation from point measurements (Fleskens and Stroosnijder, 2007). And recently, LDD's agricultural economist De Graaff (DeGraaff et al., 2011) found no evidence of the often claimed productivity decline as a result of land degradation in 8 African countries.

Our ideas at LDD are supported by some critical and famous minds like Lomborg (Albert et al., 2004). I quote Lomborg (2001): 'soil erosion may be a local problem and will often be a consequence of poverty, but the present evidence does not seem to indicate that soil erosion will to any significant degree affect our global food production, since its effects both up till now have been and in the future are expected to be heavily out weighted by the vast increase in food productivity'. In my lecture on land degradation in the Bachelor International Land and Water Management (BIL) I refer to many doom thinkers and to as many scientists that oppose this doom thinking (Koning and Smaling, 2005).

By now you may wonder: why are there so many myths and why are they so persistent. Apparently, availability heuristics influence not only the way the layman thinks about land degradation issues, but also how some scientists think (Kahneman, 2011).

In countering the doom myth, LDD is looking for cases where erosion is profitable or can be made profitable. Erosion that is often measured at the point scale creates sedimentation downstream (Bezuayehu Tefere, 2006). In some cases this causes local damage but in many other cases it creates opportunities as well (Aklilu Amsalu, 2006).

This was most strikingly illustrated with studies in Eritrea (Mehretab Tesfai, 2001) and Iran (Kheirkhah, 2005). In the coastal zone of Eritrea, water is harvested from spates (incidental floods) in wadis. This water flows from the highlands and is loaded with sediment. The loamy sandy soils of the coastal plain are very deep due to yearly sedimentation. Due to the flow, fields are irrigated with 400 mm of water and 1.5 cm of sediment. Sorghum can be grown without a single drop of rain because of the residual water stored in the deep soil. After harvesting, the Sorghum is rationed - that is the stems are cut but the root system remains intact. The roots re-sprout and a second crop can be harvested, still without any rain. Fertilization is also zero because there are enough plant nutrients in the annual sediment deposition.

Other examples of efficient use of sediment originate from wind erosion. The nearby Kootwijkerzand area, not only famous for recreation but also for habitat and rare species, remains an area with drifting sand thanks to the management proposed by LDD (Riksen, 2006). And we re-enforce our coastal dunes by making profitable use of wind erosion (DeGroot et al., 2012).

Another myth that pops-up in numerous research proposals is that there are:

'Proven' rainfall changes due to climate change

We have analysed a large number of time series of daily precipitation in Zimbabwe (Nyakudya and Stroosnijder, 2011), Tanzania (Slegers, 2008), Ethiopia (WoldeAmlak Bewket, 2003), Burkina Faso (Stroosnijder, 2007) and Benin (Mazu, 2013) and have found no significant evidence of changes in rainfall. In conclusion: Neither land degradation or rainfall changes are threatening our world (The Royal Society, 2009; Nature, 2010). A change in land use and in land quality that is called land degradation might often be better called land development (Stroosnijder, 1997). As the world and mankind develops, so do the soils and the land.

Collective wisdom on droughts suggests that crop growth is limited by low rainfall. However, in many cases it is a myth that:

In African drylands crop growth is limited by low rainfall

In African drylands, the ratio of seasonal crop transpiration over seasonal rainfall is on average as low as 15% while in a comparable climate in the Great Plains of the US it can be 55%.

We distinguish two types of droughts: one due to climate and one due to desertification (desertification is land degradation in drylands). Meteorological drought is defined as a period during which a region receives consistently below average precipitation. We have proven that in many cases, while everybody talks about drought, there is no significant reduction in rainfall (Araya Alemie, 2011).

So, the second form of drought – desertification drought - is more likely and that is what farmers mean with drought. Desertification drought can be due to lack of available water, lack of plant nutrients (Breman, 2012) or both (Zougmoré, 2003). Desertification causes changes in soil properties that lead to high losses of rainwater, such as runoff, soil evaporation and drainage below the root zone (Stroosnijder and Kiepe, 1998). So, it is not lack of rainfall but lack of soil quality that make plants suffer from 'drought'.

A wide variety of measures exist to mitigate these water losses and to alleviate nutrient stress (Hoogmoed, 1999; Stroosnijder 2003; Biamah, 2005; Stroosnijder, 2009; Birhanu Biazin, 2012).

Unmasking the myth of lack of rainfall and increasing farmers' awareness of the causes of their drought can increase the use and effectiveness of appropriate coping strategies. These factors together can lead to agricultural intensification with optimal use of the water gained through water conservation practices. These can increase the Rain Water Use Efficiency from the present 15% to, for instance, 30% which has the potential to double food production.

There is a toolbox full of measures that can be used to mitigate local Land Degradation (Schwilch et al., 2012). It is possible to transfer best practices from one desertification site to another. However, adaptation to the local context, thorough field testing, and careful balancing between the ecological, economic and socio-economic impacts is necessary (Schwilch, 2012), Figure 2.

Figure 2 Example of local water conservation: infiltration pits in channels upstream of conservation ridges in Zimbabwe (Photo by Innocent Nyakudya)

Miracles with respect to mitigation measures do not exist although some people like or want to believe they do. A few months ago I got e-mails from Martin Kropff and Aalt Dijkuizen (tipped off by Jan Peter Balkenende) that there was an amazing new technology against desertification: contour trenching. With only 100 mm of rain, runoff water first penetrates in these trenches. Later-on capillary rise brings that water upwards so that the earth is saved from below and the land becomes green again. This creates drinking water for humans and animals, restores soil fertility and made cropping and grazing possible. My reaction was that it would be interesting to have a Wageningen student scientifically prove this miracle and see how it can be spread around the world. It is a pity that I never heard from the foundation again, and thus we are unable to validate or reject this miracle.

What does exist are validated practices whereby farmers make a profit and, at the same time, natural resources are restored. A situation referred to with the terrible expression: win-win. An example is the use of the Jatropha shrub as field borders in Mali. The borders act as barriers against runoff and erosion while the Jatropha nuts are collected in a cooperative where bio-diesel is made out of them. The bio-diesel factory is jointly owned by farmers and a private investor supported by the Royal Tropical Institute in Amsterdam.

What is also a myth is that:

Measures that land degradation only works at the larger scale and small scale actions (at the farm level for instance) do not have a significant effect

I argued before that in drylands, where LDD is most important, natural and human resources show a much higher spatial and temporal dynamic than in our developed world. This has important consequences for the adoption of measures for mitigating land degradation. In drylands for instance, there can be rain and good production in one village and drought, crop failure and famine in another village 10 km away.

A clear example of what damage this myth does is the Great Green Wall. Due to temporal variation in rainfall in the Sahel the boundary between desert and savannah moves northwards (in a couple of consecutive years with good rainfall) and southwards (in a couple of consecutive dry years) over hundreds of km. This means that a fixed conservation measure like a Great Green Wall in the Sahel - 40 km wide, 8000 km long and costing around 120 m$ (GEF) - is a failure before it even starts.

Climatologists claim, based on their global circulation models, that a small forest of 1 ha can have no effect on rainfall. But farmers in many countries know for sure: vegetation attracts rain - as can be seen in Figure 3. How large the effect of a small forest is, is currently under investigation by an LDD PhD student in the Central Rift Valley of Ethiopia (Alemayehu Muluneh, 2011).

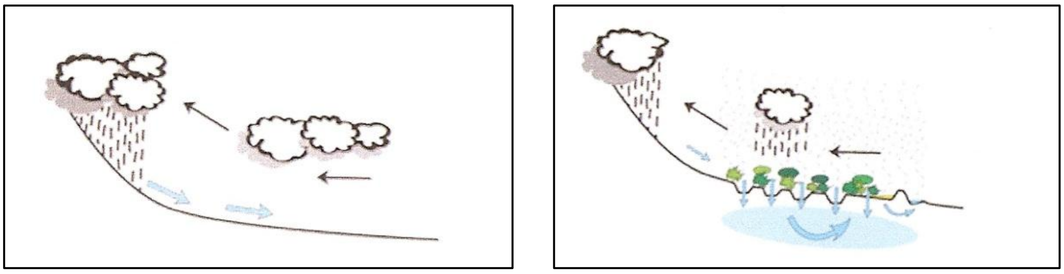

Figure 3 Picture showing how farmers belief that small scale forest will induce rain (picture: Naga Foundation)

A striking observation from an overview of the more than 50 LDD PhD theses is the important role of vegetation in mitigating local land degradation (Hien, 1995; Azene Bekele, 1997; Mayus, 1998; Rietkerk, 1998; Spaan, 2003; Selamyihun Kidanu, 2004; Fleskens, 2007; Sparrius, 2011; Youssef, 2012). Whether it is a crop, a tree or a weed does not matter for LDD. Vegetation first of all provides cover that protects the soil and it has a positive influence on the micro climate. One of the advantages of the African agroforestry system known as parkland for instance is the capture of dust as fertilizer (Sterk, 1997; Visser, 2004; Leenders, 2006). Growing vegetation makes better use of rainwater which decreases all the losses of the rainwater. Part of the green biomass returns to the soil and that is good for soil fauna and indirectly for the physical soil properties (Mando, 1997; Ouedraogo, 2004; Zida, 2011). And, most important for a farmer, a win-win situation can often be achieved through a combination of protection and production.

The large temporal dynamics of rainfall like extremes in rainfall intensity (100 mm per hour) and amount (100 mm in 1 shower) cause problems in the design of conservation measures. Actually this was already a central theme of my inaugural address in 1990 (Stroosnijder, 1991) with the title '*verdrinken of verdrogen*' (drowning or drought), Figure 4. Mitigating measures therefore, should always be semi-permeable which implies that excess water can drain so that water logging or breaching is avoided. Two examples: stone lines and vegetation barriers, Figure 5.

Figure 4 Title of Leo Stroosnijder's inaugural address in 1990: '*Verdrinken en Verdrogen*'. It expresses the extreme variation in rainfall in semi-arid regions that affects the design of conservation measures.

Figure 5 Example of semi-permeable conservation measures for semi-arid regions that block runoff and sediment at medium rainfall but allow drainage at extreme rainfall. Top: stone lines, bottom vegetation barriers.

I'll conclude my comments on MEASURES by saying that small scale actions can work very well; small is beautiful! What is small can become big and I refer again to the theory of the bottom of the pyramid: there are millions of small scale farmers. Treat them as individual entrepreneurs because there is a tendency amongst farmers to individualize. There is mistrust in leaders & managers everywhere and farmers are turning away from collective institutions (Tesfaye Beshah, 2003).

Part 3 MODELS

And now I turn to MODELS. There are two myths related to the physical side of LDD. The most common and well known myth is that:

Investing in getting more detailed physical process knowledge will help to mitigate Land Degradation

To summarize this myth: We think that we are able to feed more detailed process knowledge into models, while having limited measuring opportunities, and that this will result in a valid outcome. In my opinion this is not true and this line of research will not help to mitigate land degradation.

Let me explain this. Water erosion is the most important degradation process of the 10 degradation processes distinguished by the European Union. The impact of rain drops on the soil surface causes splash of soil particles. This is an important erosion process at the point scale. However, if the splashed particles are not transported there will be no detectable erosion at higher scale level. As Kiepe's (1995) PhD title states: 'no runoff, no soil loss'. This implies that, in order to quantify erosion, we have to study the field water balance, i.e. the flow of water over or into and through the soil. Of crucial importance thereby is the role of the soil surface with its highly dynamic structure due to soil tillage, trampling by cattle, crusting due to disaggregation, (Stroosnijder and Koorevaar, 1972; Stroosnijder and Hoogmoed, 1984), soil water repellency (Stoof et al., 2011) and many more processes, Figure 6.

Figure 6 Crusted top soil in northern Benin. The top mm of the soil has a highly dynamic structure due to soil tillage, trampling by cattle, crusting due to disaggregation, soil water repellency and many more soil processes of which many still remain unknown

In spite of the many years that soil physicists have spent on these phenomena, there can be only one conclusion: to date we do not understand or cannot adequately describe what happens with energy (Stoof, 2011), liquid (Stroosnijder, 1987) and vapor flow (TenBerge, 1986) in the top mm of the soil. Scale and landscape much affect land degradation processes. After 80 years of process studies, the United States Soil Conservation Service thinks that they understand erosion processes at the field scale but must admit that they have no idea how to predict, with a deterministic model using physical laws, the quality of the water in a river that receives its water from adjacent fields.

LDD has always spent a lot of research on processes (Wesseling, 2009), both in the field and in the laboratory with help of rainfall simulators, wind tunnels and remote sensing (Vrieling, 2007). Conclusions from the first of these detailed measurements in the lab with double gamma rays in 1974 (Stroosnijder and DeSwart, 1974), do not differ from the last in 2012 (Ali, 2012; Ali et al., 2012): many basic questions on soil processes still remain unanswered (Baveye et al., 2011).

But even when we know more at the mm scale, the conceptual and contextual understanding of how we can upscale this knowledge to the physics at landscape and watershed scale is still inadequate. However, in my opinion there is no need to know more physical details. For an applied science as LDD, current soil physical knowledge is sufficiently mature. Simple, semi-empirical equations work very well in most circumstances and are still widely used (Stroosnijder, 1982). It is not ever more detailed soil physics but more conceptual understanding and modeling at higher scale levels that will bring us further. That is why it is a myth that investing in more detailed physical process knowledge will help to mitigate Land Degradation. One example of this thinking at a higher scale level is LDD's recent grant from the National Science Foundation on sediment 'connectivity' in a landscape using a mix of graph theory, geomorphology, field measurements and spatial modeling (Keesstra, 2012).

And now, the myth on measurements and modeling:

We can measure and model LDD

There's a Dutch saying: '*meten = weten*' (measuring is knowing) and LDD has always committed itself to maintain a soil physics lab, the water and sediment lab and a large stock of field equipment that PhD students could use for their field work. We also cooperate closely with Royal Eijkelkamp, a large Dutch firm specialised in equipment for soil and water research. We have developed equipment together, like a portable rainfall simulator that can be used in remote mountainous terrain, and the saltiphone that detects saltating particles, Figure 7.

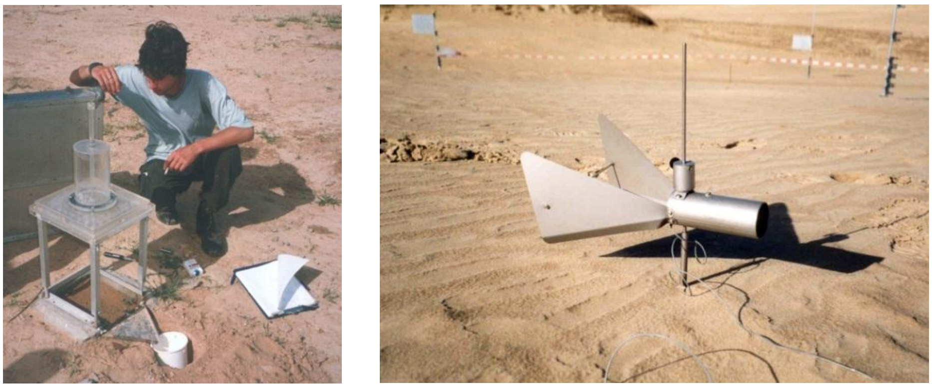

Figure 7 Two examples of equipment that the Land Degradation and Development Group developed together with Royal Eijkelkamp. Left, a mini rainfall simulator for use in remote areas. Right, the saltiphone that detects the flow of saltation particles in wind erosion.

All these investments were aimed at measuring land degradation directly or indirectly in the form of relevant governing processes like runoff, sediment yield, etc. But in practice we often question the meaning of what we have measured which leads me to the myth that we can measure and model LDD. An example was described by Vigiak (2005) In all hydrological catchment models, the most sensitive parameter for runoff appeared to be the soil's field saturated hydraulic conductivity. However, measurement of this parameter with three different methods gave values that are out of range with the value that was needed to calibrate the model with hydrological measurements (Vigiak et al., 2006). Also in a more recent PhD study, (Baartman, 2012) the value for Ksat has to be adapted for each rainfall event in order to calibrate the model that was used. And it is not simple to bridge event and continuous hydrological modeling (Sheik, 2006).

A problem with measurements is that soil physical properties may vary significantly over short distances and times (Okoba, 2005). Precise point measurements therefore are of limited use. Therefore we have looked in LDD for methods that cover higher space and time scales (VanLoon, 2002; Romero, 2005). A problem with measurements related to the temporal scale is the duration of measurements. Figure 8, for instance, presents rainfall data from Burkina Faso.

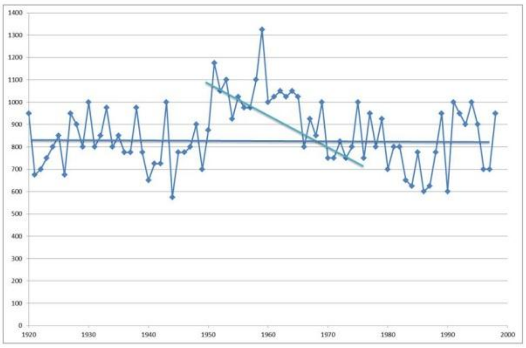

Figure 8 Example of the influence of measurement duration of temporal data: rainfall data from Burkina Faso. At the 40 year period from 1950 to 1990 we observe a dramatic decrease from 1100 to 700 mm. However, if we extend our observation from 40 to 80 years, the dramatic decline disappears and we get a mean rainfall of 820 mm.

When we look at the 40 year period from 1950 to 1990 we observe a dramatic decrease from 1100 to 700 mm. That has indeed induced significant land use changes and affected the minds and memory of a whole generation of farmers. Climate change! Drought! But, if we extend our observation from 40 to 80 years, our dramatic decline disappears and we get our mean rainfall of 800 mm back.

In measurements there is also an ethical issue. Ethics of scientists has become a hot topic over the last year! There is only one way out - and that is to provide more access to primary data. Making primary data available for peers can help to overcome this problem. That is what the Dutch Organisation for Scientific Research nowadays requires and partners like Deltares and Ecoshape practice. Wageningen Library is implementing this in the Wageningen research community.

In conclusion: measurement of land degradation is very difficult, if not impossible (Stroosnijder, 2005; Fleskens and Stroosnijder, 2007). This often means that empirical evidence about a number of crucial physical processes - like the loss of precious soil water due to soil evaporation (Stroosnijder, 1987) - is still inconclusive.

My concern that measurements of Land Degradation should be judged with great care also applies to models. Let me illustrate this with an example that again stresses the Cultural Economy of developing regions. In the large interdisciplinary INRES project in Malang, East Java we modeled challenges for Land Development in an area with very poor biophysical and socio-economic conditions. The outcome of 2 PhD's (VanRheenen, 1995; Efde, 1996) was that there were very few opportunities to stop Land Degradation and to initiate Land Development. By chance, I re-visited that area 5 years later and to my surprise I saw a lot of conservation and even prosperity. The unexpected, and exact opposite of what we modeled, had occurred! How was that possible? Well, in every village I saw a recruitment office for work in Singapore, Hongkong or the Middle East. Apparently, money from paychecks was invested in land improvement, which was totally unforeseen in our model. I do not know whether this frustrated the 2 PhD's in hindsight: but one disappeared to Washington and the other became alderman of the city of Wageningen.

Being a student of Cees de Wit, I modeled infiltration into swelling soils in the early seventies (Stroosnijder, 1976). This wasn't easy since the moisture characteristic (i.e. the relation between the moisture content of the soil and its potential) was only vaguely defined (Stroosnijder and Bolt, 1984). The resulting complicated model had only limited value for practical problems with swelling and shrinking soils. And that is the general idea that I still have 40 years later about such physical modeling.

Models are only part of reality and never better that the quality of the input data. Models have become more complex giving rise to a number of problems. (Hengsdijk et al., 2005 and Nyssen et al., 2006). The first is the lack of availability of input data. Measurements are expensive, more and more laboratories are closed and technicians disappear. Many users of models lack insight into the ins- and outs of modeling and consequently misuse the tool of modeling. They run a model in Ghana for instance, and due to lack of local data, use 80% of the default values which were developed for Drenthe in The Netherlands.

A second problem is that of equifinality (Beven, 1996), i.e. that different sets of input parameter values give the same modeling output. This is the result of too many parameters, which is so characteristic of ever more complex models. This led Beven, at the end of a long career in hydrology, to conclude: 'given the limitations of our measuring techniques, the aim of defining a model of a catchment system that properly describes the processes actually governing the catchment response is essentially unattainable'.

A third problem is that there are no ways to check modelers' ethics. Each model needs validation, but before that it needs calibration. And during that process a lot can 'go wrong' - or be manipulated -, certainly in a time of tenure track and publish or perish (Stocking, 1995). Again from Beven: 'There have been very few rejections of models on the grounds of comparison with observations. Something can always be changed to improve the goodness of fit' (Beven, 2001).

So you can hear that I do not share the optimism of those that pretend to predict land use changes using complicated models (Veldkamp and Lambin, 2001). That is not to say that models have no use. They are valuable tools for organizing the mind and our thinking - but their value for predicting as well as exploring is limited. And, I am convinced that simple models work as well and in many cases even better. The persistent use of the Universal Soil Loss Equation (USDA-NRCS, 2002) is an example (Sonneveld et al., 2011). Another example (Stroosnijder, 1996) describes the effect of grazing on infiltration, runoff and primary production in the Sahel. Such models use a limited input set and often work at a specific scale level but are not worse than the more complex models. Again: small is beautiful!

There are at least four different approaches to overcome what I call 'the modeling crisis'. The first is to see modeling as collective intelligence (Beven, 2001)whereby an unknown situation can be better handled based on our experience with a comparable situation elsewhere or in the past. A second way out is to consider modeling more imagination, inspiration, creativity, ingenuity, experience and skill than hard fact. These are qualities that belong to the field of art, hence modeling LDD is an art as much as it is a science of engineering (Savenije, 2009). The third is a matter of scale. Instead of looking into more and more detail we should zoom out and do more averaging over space and time whereby the world becomes more regular and predictable. An LDD PhD thesis by VanLoon (VanLoon, 2002) entitled: 'overland flow: interfacing models with measurements' goes in that direction. The most recent way to overcome the gap between biophysical modeling and reality is to take more human behavior into account, in other words include the MAN! (VanPaassen, 2004), figure 9. Role playing games which are part of Agent Based Modeling help to understand the MAN factor and achieves more than the current bio-physical modeling (Bui Tan Yen, 2012; Schoolenberg, 2012).

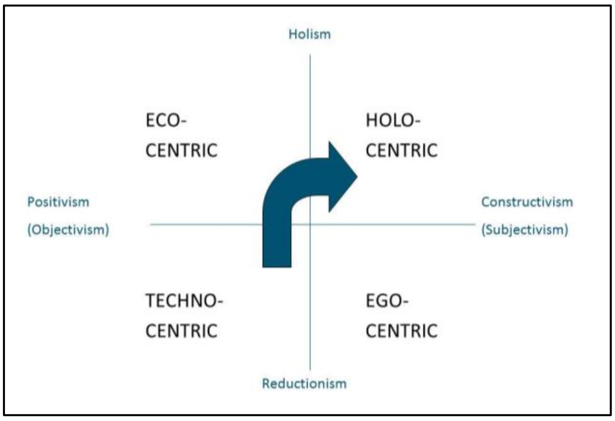

Figure 9 Example of taking more human behavior into account in our research. Systems modeling based on positivism and holism should also deal with constructivism.

Part 4 Capacity building

Ladies and gentlemen, with all these myths maybe you'll get the idea that we don't know what should be done to mitigate local land degradation and stimulate land development. But I can assure you that this is not the case! We make students think about these myths which stimulates them to become more critical scientists. We challenge them to think out-of-the-box for new ideas and directions. If you are interested in how we do that, you should register for our Master in International Land & Water Management. For next September we still have a limited number of places left!

Our study program is just one example of the capacity building that we do. The LDD Group keeps in close contact with its PhD alumni because we want to know about possible changes in the demand for capacity building and we want to learn from their experiences (Stroosnijder et al., 1994). That is also why I was chief editor of the series Tropical Resource Management Papers. The idea was to distribute for free a large number of thesis copies in the countries where the research was done. A total of 100 PhD reports were published over the last 20 years.

My farewell address today is part of a special capacity building session of the 8th International Symposium Agro Environ that is currently going on in Wageningen. Keynote speaker is Eric Smaling, currently director of Development, Policy and Practice at the Royal Tropical Institute in Amsterdam. His topic is 'Brains for African Land & Food'. The rapid transfer of 'the lost continent' into a highly dynamic society with boosting economic growth figures but also suffering from land grabbing (Kessler et al., 2012) needs a new generation of 'African Agribusiness Brains'. We can help with curricula development in Africa to create scientists who can lead and support development from within. Development that covers the entire range from sound management of scarce natural resources to agribusiness, and from safety net development for the needy and the refugee, to improved producer-market relations and commercial, sustainable food chain development (Gabre-Madhin and Haggblade, 2004).

Many of the more than 50 LDD alumni are present today and four alumni gave an oral presentation about individual, institutional and society benefits of their PhD in the LDD Group in Wageningen. Of course many benefits are obvious; I will only present here some remarkable issues. With respect to individual benefits, highlights are: (1) gained self-confidence through knowledge and skills learned in Wageningen is highlighted, (2) greater political awareness, (3) rapid career (Minister, Head of department, vice Dean, etc) and (4) well paid consultancies (sometimes a drawback).

Institutional befits that are often mentioned: (1) copying of the Wageningen PhD system (with regulations, quality control, etc), (2) advocacy of interdisciplinary research, (3) international jobs (WB, CGIAR system), (4) presentation skills at international conferences and (5) writing skills for grant and project proposals.

At society level: (1) high leverage policy influence (at ministerial level) is considered the most important achievement, (2) no white collar scientists, (3) appreciation of local knowledge and (4) the potential of small farmers, jobs in professional societies like the Soil Science Society of Africa. Major advantages mentioned for 'Development' are: Capacity building lasts a life time: much longer than an average project. And the 'no white collar' scientists from Wageningen allow to stimulate development from within. This is crucial because development aid by rich western countries so often aims at their own diplomatic and economic goals (Muambi, 2012) rather than at African development. Development therefore must come from 'within' (Ostrom, 2009).

There are also challenges mentioned by our alumni: (1) more open access publications, (2) a Wageningen alumni fund for a 2 months stay at their Alma Mater (during sabbatical) and (3) more collaboration with home institutes of alumni. These activities will lead to 'Brain circulation', i.e. no brain drain or gain but a situation where scientists communicate on a level playing field and equal wave length.

Part 5 THANKS

Friends, family, colleagues and colleague professors, I have come to the end of my farewell address.

Every scientific career has a starting point, and mine dates back 55 years. Every Sunday morning I was crouched by the radio listening to the VARA radio talk by Fop I. Brouwer: '*Alles wat leeft en groeit en ons altijd weer boeit*'. Fop I. Brouwer talked in an inspiring manner about love for nature in a socialist context, and the 10-year old me was so fascinated by the subject that I wrote him a letter asking him how to become a specialist on the subject. He told me to become a Field Biologist but that was only possible with an HBS diploma. So I got the message; enrolled in a 5-year HBS program in Amsterdam and later as a student in Wageningen. And over the years the subject changed from Biology to Soil Physics.

The start of a scientific career also has an invisible backbone, the family. The family because they often take over day-to-day duties. This made it possible that I did my own PhD. My, then young, children Aernout, Ingeborg and Sanne had to travel all over the world to Mali, Indonesia and the US to follow my professional duty stations and therefore had to miss Dutch friends (although I am sure that they became world citizens in the process). And also the broader family, that supports me in occasions like this farewell address today (you were already there when I defended my PhD thesis) and you surround me with the warmth of your presence.

For the start of my career I thank professor Bolt, who was my PhD promotor. Thank you for trusting me (a leftist student) enough to hire me as a staff member with 30% of my time to be spent on a PhD. Those were different times! (Stroosnijder, 1996) I have to give him special gratitude for allowing me to use his official toga dress for all these years. Now that I am bidding my farewell I can confess that I never owned my own and always used his.

Students play a special and important role in the life of a chairholder. They come in as freshman, unprejudiced, young and raw, with curious minds to learn about the subject of International Land and Water Management. Over the years the name of the study program has changed many times, and of course also the student attitudes towards the field have changed. But what has remained is their interest in better opportunities for land and water management in developing countries and their wish for a better world. They graduate as mature MSc students, ready for a professional or scientific career. These students represent the future, and I would like to thank the many students that passed through during my career for their interest and enthusiasm (Heijmans, 2011).

A special group of students are the PhD students; I have referred to their work many times during this farewell address. Today four of you explained why you chose Wageningen, and how this affected your careers in your home countries. It has always been my pleasure to work with you, to guide you in becoming a scientist with a questioning mind; and I always enjoyed travelling to your countries, to see the day to day reality that you face in your work.

For my 20 years in Soil Physics at the Dreyen, I owe thanks to many colleagues. They had to take over teaching while I was in Mali and Indonesia. Moving from the Dreyen to The Nieuwlanden for a new challenge brought me into contact with very knowledgeable, practical and motivating people like Leo Eppink, Wim Spaan and Dirk Meindertsma. I learned a lot from you and I would like to thank you for that.

My first newly hired staff member at The Nieuwlanden was an experienced agricultural economist Jan de Graaff. Jan formed the basis of our interdisciplinary group and, as you may have understood from my farewell address, he inspired the 'man' element in our scientific field. Measurements and practicals are important for which a number of staff members are to be thanked: I want to mention Fred de Klerk and Piet Peters in particular, who were always very helpful and inventive in finding solutions to practical problems in the field.

In a turbulent time I was Primus Inter Pares of the Soil Science Cluster for a couple of years. Since that time Coen Ritsema became part time professor in the LDD Group and helped a lot with the acquisition of many PhD projects. I also owe many thanks to my current staff, almost too many to mention: Michel, Aad, both Saskia's, Demie and an anchor in many storms Marnella. The current LDD group, now in the ATLAS building at the campus, had to deal with the uncertainty of LDD's future for more than 2 years, but a solution seems to be at hand.

Although the next years will still keep me busy with finishing 14 more PhD's, I am glad to have more time to relax with my now grown children, their partners, my grandchildren and Alco and Laura. I will also enjoy the sunny side of life, preferably on an enjoyable terrace with a glass of wine, with my much beloved Jacquelijn.

Last but not least I would like to thank Pim Brascamp, our vice Rector Magnificus to day and Wageningen University at large for over 45 years of employment.

I wish you all the best and farewell.

References

Aklilu Amsalu, 2006. Caring for the land: best practices in soil and water conservation in Beressa watershed, highlands of Ethiopia. Doctoral thesis Wageningen University, 149 p., ISBN 90-8504-443-X

Albert, K-D, J. Mueller, J.B. Ries and I. Marzolff, 2004. Desertifikation: zwischen Katastrophenszenario und Myhtenbildung (p. 292-295). In: Albert, K-D, D. Loehr and K. Neumann (eds.). Mensch und Natur in Westafrika. Wiley.

Ali, M. (Mazhar), 2012. Sediment transport capacity for soil erosion modelling at hillslope scale: an experimental approach. Doctoral thesis Wageningen, 120 p., ISBN 978-94-6173-131-9

Ali M., Sterk G., Seeger M. and L. Stroosnijder, 2012. Effect of flow discharge and median grain size on mean flow velocity under overland flow. Earth Surface Processes and Landforms (accepted).

Araya Alemie, 2011. Coping with drought for food security in Tigray, Ethiopia. Doctoral thesis Wageningen University, 172 p., ISBN 978-90-8585-925-3

Azene Bekele, 1997. A participatory agroforestry approach for soil and water conservation in Ethiopia. Doctoral thesis Wageningen Agricultural University, 229 p., ISBN 90-5485-763-3.

Alemayehu Muluneh, 2011. Strategies to adapt to climate change in the Central Rift Valley of Ethiopia: Linking regional drought stress patterns to on-farm water management. WIMEK PhD proposal.

Baartman, J.M. (Jantiene), 2012. Mind the gap: Modelling event-based and millennial-scale landscape dynamics. Doctoral thesis Wageningen, 216 p., ISBN 978-94-6173-266-8

Baveye, P.C., D. Rangel, A.R. Jacobsen, M. Laba, C. Darnault, W. Otten, R. Radulovich and F.A.O. Camargo, 2011. From Dust Bowl to Dust Bowl: soils are still very much a frontier of science. SSAJ 75: 2037-2048

Beven K. 1996. Equifinality and uncertainty in geomorphological modelling. In The Scientific Nature of Geomorphology, Rhoads BL, Thorn CE (eds). Wiley: Chichester, UK; 289–313.

Beven, K., 2001. On modelling as collective intelligence. Hydrological Processes 15, 2205–2207.

Bezuayehu Tefera , 2006. People and Dams: environmental and socio-economic changes induced by a reservoir in Fincha'a watershed, western Ethiopia. Doctoral thesis Wageningen University, 138 p., ISBN 90-8504-449-9

Bewket, W.A. (WoldeAmlak), 2003. Towards integrated watershed management in highland Ethiopia: the Chemoga watershed case study. Doctoral thesis Wageningen University, 169 p., ISBN 90-5808-870-7.

Biamah, E.K. (Elija), 2005. Coping with drought: options for soil and water management in semi-arid Kenya.
Doctoral thesis Wageningen University, 119 p., ISBN 90-8504-178-3.

Birhanu Biazin, 2012. Rainwater harvesting for dryland agriculture in the Rift Valley of Ethiopia. Doctoral thesis Wageningen, 152 p., ISBN 978-94-6173-215-6

Bidogeza J.-C. (Jean-Claude), 2011. Bio-economic farm modelling to analyse agricultural land productivity in Rwanda. Doctoral thesis Wageningen, 184 p., ISBN 978-90-8585-956-7

Bodnar, F. (Ferko), 2005. Monitoring for impact: Evaluating 20 years of soil and water conservation in southern Mali.
Doctoral thesis Wageningen University, 219 p., ISBN 90-8504-282-X

Breman, H., 2012. The Agro-ecological solution!? Food security and poverty reduction in sub-Saharan Africa, with an emplasis on the East Afrocan Highlands. Invited lecture:

Bui Tan (Yen), 2012. Integrated modelling of erosion assessment, land use decision making and adoption of recommendations in North Vietnamese uplands. Doctoral thesis Wageningen

DeGraaff, J. (Jan), 1996. The price of soil erosion: an economic evaluation of soil conservation and watershed development. Doctoral thesis Wageningen Agricultural University, 300 p. ISBN 90-6754-459-0.N

DeGraaff, J., Kessler, C.A., Nibbering, J.W., 2011. Agriculture and food security in selected countries in Sub-Sahara Africa: diversity in trends and opportunities. Food Security 3:195–213

DeGroot, A.V., S. de Vries, J.G.S. Keijsers, M.J.P.M. Riksen, Q. Ye, A. Poortinga, S. M Arens, L.M. Bochev-Van der Burgh, K.M. Wijnberg, J.L. Schretlen, J.S.M. van Thiel de Vries, 2012. Measuring and modeling coastal dune development in the Netherlands, Proceedings, NCK

DeRidder, N., L. Stroosnijder & A. M. Cissé, 1981. La production des pâturages Sahéliens: Une étude des sols, des végétations et de l'exploitation de cette ressource naturelle. 'Cours PPS'. Tome I: Theorie, 237p. Tome II: Travaux pratiques, 139 p. L'Université Agronomique Wageningen, Pays-Bas.

Efdé, S.L. (Stella), 1996. Quantified and integrated crop and livestock production analysis at the farm level: exploring options for land use of mixed farms on heavy limestone soils south of Malang, East Java, Indonesia. Doctoral thesis Wageningen Agricultural University, 230 p. ISBN 90-5485-496-0.

Erenstein, O.C.A. (Olaf), 1999. The Economics of Soil Conservation in Developing Countries: The case of crop residue mulching. Doctoral thesis Wageningen Agricultural University, 302 p., ISBN 90-5808-089-7.

FAO, 2011. The state of the world's land and water resources for food and agriculture. Rome.

Fleskens, L. (Luuk), 2007. Conservation scenarios for olive farming on sloping land in the Mediterranean. Doctoral thesis Wageningen, 219 p., ISBN 978-90-8504-717-9.

Fleskens, L. and L. Stroosnijder, 2007. Is soil erosion in olive groves as bad as often claimed? Geoderma 141: 260-271.

Folmer, H., 2012. De economen weten het echt niet. Opinie & Debat, Volkskrant, 06.01.2012.

Gabre-Madhin, E.Z. and S. Haggblade, 2004. Successes in African agriculture: results of an expert survey. World Development 32:745-766.
Heijmans, C.F., 2011. International Land and Water Management: critical reflection 2011. Wageningen University, 42 pp.
Hengsdijk, H., Meijerink, G.W., Mosugu, M.E., 2005. Modelling the effect of soil and water conservation practices in Tigray, Ethiopia. Agric. Ecosyst. Environ. 105, 29–40.
Hien, F.G. (Fidele), 1995. La régénération de l'espace sylvo-pastoral au Sahel. Une étude de l'effet de mesures de conser-vation des eaux et des sols au Burkina Faso. Doctoral thesis Wageningen Agricultural University, The Netherlands.
Hoogmoed, W.B. (Willem), 1999. Tillage for soil and water conservation in the semi-arid tropics. Doctoral thesis Wageningen Agricultural University, 184 p., ISBN 90-5808-7026-9.
Kahneman, D., 2011. Ons feilbare denken: thinking, fast and slow. Business Contact Amsterdam, 527 p.
Kheirkhah, M. (Mirmasud), 2005. Decision support system for floodwater spreading site selection in Iran. Doctoral thesis Wageningen University, 259 p., ISBN 90-8504-256-9
Keesstra, 2012. Getting a grip on sediment connectivity in landscapes: introducing graph theory and geomorphology in field methodology and spatial modelling. NWO Open Programme Proposal.
Kessler, A. (Aad), 2006. Moving people - towards collective action in soil and water conservation. Experiences form the Bolivian mountain valleys. Doctoral thesis Wageningen University, 195 p., ISBN 90-8504-476-6.
Kessler C.A. et al., 2011. Grab & Grow: an interdisciplinary perspective on large-scale land appropriations. Research proposal submitted for the Interdisciplinary Research and Education Fund of Wageningen University (INREF). Wageningen University, 34 pp.
Kiepe, P. (Paul), 1995. No runoff, no soil loss: soil and water conservation in hedgerow barrier systems. Doctoral thesis Wageningen Agricultural University, The Netherlands, 156 p.
Koning, N. and E. Smaling, 2005. Environmental crisis or 'lie of the land'? The debate on soil degradation in Africa. Land Use Policy 22 (2005) 3–11
Leenders, J. (Jakolien), 2006. Wind erosion control with scattered vegetation in the Sahelian zone of Burkina Faso. Doctoral thesis Wageningen University, 170 p., ISBN 90-8504-400-6
Lomborg B, 2001. Should we worry about erosion? P 104-106 in: The skeptical environmentalist: measuring the real state of the world. Cambridge University Press.
Mando, A. (Abdoulaye), 1997. The role of termites and mulch in the rehabilitation of crusted Sahelian soils. Doctoral thesis Wageningen Agricultural University, 103 p., ISBN 90-5485-700-5.
Mazu, A. (Abraham), 2013. Improving rainwater use efficiency in North Benin. Doctoral thesis Wageningen.
Mazzucato, V. (Valentina) and D. (David) Niemeijer, 2000. Rethinking Soil and Water Conservation in a Changing Society: a case study in Eastern Burkina Faso. Doctoral thesis Wageningen Agricultural University, 380 p., ISBN 90-5808-2504.
Mazzucato V and D Niemeijer, 2001. Overestimating land degradation, underestimating farmers in the Sahel. Issue paper no. 101, IIED, 22 p.
Mayus, M. (Martina), 1998. Millet growth in windbreak-shielded fields in the Sahel: experiment and model. Doctoral thesis Wageningen Agricultural University, 250 p., ISBN 90-5485-763-3.
Mehreteab Tesfai, 2001. Soil and Water Management in Spate Irrigation Systems in Eritrea. Doctoral thesis Wageningen Agricultural University, 211 p., ISBN 90-5808-388-8.
Muambi, A., 2012. Gates belde met de verkeerde instanties. Volkskrant Opinie & debat, 03.04.2012.
Mutekanga, F.P. (Fiona), 2012. Participatory Policy Development for Integrated Watershed Management in the Uganda Highlands. Doctoral thesis Wageningen.
Nabahungo, L. (Leon) Problems and opportunities of wetland management in Rwanda. Doctoral thesis Wageningen, 136 p., ISBN 978-90-8585-924-6
Nature (editorial), 2010. How to feed a hungry world. Nature 466/7306.
Nyakudya I. W. and L. Stroosnijder, 2011. Water management options based on rainfall analysis for rainfed maize (Zea mays L) production in Rushinga district Zimbabwe. Agricultural Water Management 98: 1649-1659
Nyssen, J., Haregeweyn, N., Descheemaeker, K., Gebremichael, D., Vancampenhout, K., Poesen, J., Haile, M., Moeyersons, J., Buytaert, W., Naudts, J., Deckers, J., Govers, G., 2006. Comment on ''Modelling the effect of soil and water conservation practices in Ethiopia'' [Agric Ecosyst. Environ. 105 29-40] Agric. Ecosyst. Environ 114, 407–411.
Okoba, B.O. (Barrack), 2005. Quantification of soil erosion and sedimentation using farmers' knowledge and field measurements in the highlands of East Africa. Doctoral thesis Wageningen University, 143 p., ISBN 90-8504-157-0.
Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. Science 325: 419-422.
Ouédraogo, E. (Elysee), 2004. Soil quality improvement for crop production in semi-arid West Africa. Wageningen Agricultural University, 193 p., ISBN 90-5808-992-4.
Penning de Vries, F.W.T., Djitèye, A.M. (Eds.), 1982. La productivité des pâturages sahéliens. Une étude des sols, des vé gétations et de l'exploitation de cette ressource naturelle. Agric. Res. Rep. 918, Pudoc, Wageningen.

Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Sphpritz, L.,Fitton, L., Saffouri, R. and Blair, R.: 1995, 'Environmental and economic costs of soil erosion and conservation benefits', Science 267, 1117–1123.
Pimentel, D., 2006. Soil erosion: a food and environmental threat. Environment, Development and Sustainability 8: 119-137.
Posthumus, H. (Helena), 2005. Adoption of terraces in the Peruvian Andes. Doctoral thesis Wageningen University, 204 p., ISBN 90-8504-249-6
Prahalad, C.K. and S.L. Hart, 2004. The fortune at the bottom of the pyramid. Strategy + business 26, 432 pp.
Rietkerk, M. (Max), 1998. Catastrophic vegetation dynamics and soil degradation in semi-arid grazing systems. Doctoral thesis Wageningen Agricultural University, 155 p., ISBN 90-5485-763-3.
Riksen, M.J.P.M. (Michel), 2006. Wind borne landscapes: the role of wind erosion in agricultural land management and nature development. Doctoral thesis Wageningen University, 231 p., ISBN 90-8504-386-7
Romero, C.C. (Cecilia), 2005. A multi-scale approach for erosion assessment in the Andes. Doctoral thesis Wageningen University, 147 p., ISBN 90-8504-x
Schoolenberg, M., 2012. Creating awareness among decision makers on land degradation and sustainable land management: Farm System Analysis for the development of a computer game. LDD Group, Wageningen.
Schwilch, G. (Gudrun), 2012. A process for effective desertification mitigation. Doctoral thesis Wageningen
Schwilch, G., Hessel, R. and Verzandvoort, S. (Eds). 2012. Desire for Greener Land. Options for Sustainable Land Management in Drylands. Bern, Switzerland, and Wageningen, The Netherlands: University of Bern - CDE, Alterra - Wageningen UR, ISRIC - World Soil Information and CTA - Technical Centre for Agricultural and Rural Cooperation.
Selamyihun Kidanu, 2004. Soil and Water Conservation with Eucalyptus on the highland Vertisols of Ethiopia. Doctoral thesis Wageningen University, 197 p., ISBN 90-5808-993-2.
Sheikh, V. (Vahedberdi), 2006. Soil Moisture Prediction: Bridging Event & Continuous Runoff Modelling Doctoral thesis Wageningen University, 190 p., ISBN 90-8504-533-9.
Slegers, M.F.W. (Monique), 2008. Exploring farmers' drought perceptions in Tanzania and Ethiopia. Doctoral thesis Wageningen, 217 p., ISBN 978-90-8585-240-7.
Sonneveld, B.G.J.S., M.A. Keyzer, and L. Stroosnijder, 2011. Evaluating quantitative and qualitative models: an application for nationwide water erosion assessment in Ethiopia. Environmental Modelling & Software 26:1161 - 1170.
Spaan, W.P. (Wim), 2003. Consuming the savings: Water Conservation in a Vegetation Barrier System at the Central Plateau in Burkina Faso, Doctoral thesis Wageningen University, 207 p., ISBN 90-6754-707-7.
Sparrius, L. (Laurens), 2011. Inland dunes in The Netherlands: soil, vegetation, nitrogen depositions and invasive species. Doctoral thesis University of Amsterdam, 165 p.
Sterk, G. (Geert), 1997. Wind erosion in the Sahelian zone of Niger: processes, models and control techniques. Doctoral thesis Wageningen Agricultural University, 152 p., ISBN 90-5485-672-6.
Stocking, M., 1995. Soil erosion in developing countries: where geomorphology fears to tread! Catena 25: 253-267.
Stoof, C.R. (Cathelijne), 2011. Fire effects on soil and hydrology Doctoral thesis Wageningen, 182 p., ISBN 978-90-8585-915-4.
Stoof, C.R.,D. Moore, C.J. Ritsema and L.W.Dekker, 2011. Natural and fire-induced soil water repellency in a Portuguese shrubland. Soil Science Society of America Journal 75: 2283-2295.
Stoorvogel J.J. and E.M.A. Smaling, 1990. Assessment of soil nutrient depletion in Sub-Saharan Africa 1983-2000. Report No. 28, The Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), Wageningen, The Netherlands.
Stroosnijder, L., 1976. Infiltration in swelling and shrinking soils. Chapter 7 of 'Infiltration and Redistribution of Water in Soils' by L. Stroosnijder, 60 p. Versl. Landbouwk. Onderz. (Agric. Res. Rep.) no. 847, p.119-174. Translated from the original Dutch by T. Talsma.
Stroosnijder, L., 1982. Simulation of the soil water balance. In: F.W.T. Penning de Vries et al. (Eds), Simulation of plant growth and crop production. Simulation Monograph, PUDOC, Wageningen, p.175-193.
Stroosnijder, L., 1987. Soil evaporation: test of a practical approach under semi-arid conditions. Netherlands Journal of Agricultural Science, 35:417-426.
Stroosnijder, L. (Ed.), 1989. Interdisciplinary Agricultural Research Training at Brawijaya University (INRES). Project Document 1989-1992.
Stroosnijder, L., 1990. Soil Physics Practicals. MSc course Soil and Water, Wageningen Agricultural University, 78p.
Stroosnijder, L., 1991. Verdrinken en verdrogen. Inaugurale rede Landbouw Universiteit Wageningen, 40 p.
Stroosnijder, L., 1996. Modeling the effect of grazing on infiltration, runoff and primary production in the Sahel. Ecological Modelling, 92:79-88.
Stroosnijder, L., 1997. Andean Erosion Control: a science perspective. International Popato Center (CIP), Lima, Peru, 112 p.
Stroosnijder, L., 2003. Technologies for improving green water use efficiency in semi-arid Africa. P. 92-102 in: B. Beukes, M. de Villeirs, S. Mkhize, H. Sally and L. van Rensburg (eds.). Proceedings Water Conservation Technologies

for Sustainable Dryland Agriculture in Sub-Saharan Africa. Symposium and Workshop, Bloemfontein, South Africa.
Stroosnijder, L., 2005. Measurement of erosion: is it possible? Catena 64: 162-173.
Stroosnijder, L., 2006. De jaren zeventig: democratisering op De Dreijen. P.43-53 in: M.L. van Beusichem and K. Koenders (eds.) De Mensen van Landbouwscheikunde: een halve eeuw op De Dreijen. ESG, Wageningen.
Stroosnijder L, 2007. Rainfall and Land Degradation. P.167-195 in: Sivakumar, MVK and N. Ndiang'ui (Eds.) Climate and Land Degradation. Spinger.
Stroosnijder L, 2009. Modifying land management in order to improve efficiency of rainwater use in the
African highlands. Soil & Tillage Res. 103: 247-256.
Stroosnijder, L. and G.H. Bolt, 1984. The moisture characteristic of heavy clay soils. In: J. Bouma & P.A.C. Raats (Editors), Proc. of the ISSS Symposium on water and solute movement in heavy clay soils. ILRI publication no. 37:324-330, Wageningen.
Stroosnijder, L. & J.G. DeSwart, 1974. Column scanning with simultaneous use of ^{241}Am and ^{137}Cs gamma radiation. Soil Science, 118:61-69.
Stroosnijder L and L.A.A.J. Eppink (Eds.), 1990. An Introduction to Soil and Water Conservation, Wageningen Agricultural University, Dept. of Irrigation and Soil & Water Conservation, 200 p.
Stroosnijder, L., L.O. Fresco and S.W. Duiker, 1994. The Future of the Land. Land Use Policy, 11:237-240.
Stroosnijder, L. & W.B. Hoogmoed, 1984. Crust formation on sandy soils in the Sahel; II: Tillage and its effects on the water balance. Soil & Tillage Research, 4:321-337.
Stroosnijder, L. and P. Kiepe, 1998. Simulation of Maize Growth under Conservation Farming in Tropical Environments. Tropical Resource Management Papers no. 19, 90 p. Wageningen University, ISBN 90 6754 550 3.
Stroosnijder, L. & P. Koorevaar, 1972. Air pressure within soil aggregates during quick wetting and subsequent 'explosion'. Med. Fak. Landbouwwetenschappen, Ghent, vol. 37(3):1095-1106.
Stroosnijder, L. and T. VanRheenen (eds.), 2001. Agro-Silvo-Pastoral Land Use in Sahelian Villages. Advances in GeoEcology 33. CATENA VERLAG GMBH, 408 p.
TenBerge, H.F.M. (Hein), 1986. Heat and Water Transfer at the bare soil surface.
Doctoral thesis Wageningen University, 214 p + Annexes
Tenge, A.J.M. (Albino), 2005. Participatory appraisal for farm level soil and water conservation planning in Usambara highlands in Tanzania.. Doctoral thesis Wageningen University, 163 p., ISBN 90-8504-165-1
Tesfaye Beshah, 2003. Understanding Farmers: Explaining Soil and Water Conservation in Konso, Wolaita and Wello, Ethiopia. Doctoral thesis Wageningen University, 245 p., ISBN 90-5808-795-6.
The Royal Society, 2009. Reaping the benefits: science and the sustainable intensification of global agriculture. ISBN: 978-0-85403-784-1
Traore K. (Karim), 2006. Effects of soil amendments and drought on Zinc husbandry and grain quality in Sahelian sorghum. Doctoral thesis Wageningen University, 162 p., ISBN 90-8504-437-5
USDA-NRCS, 2002. RUSLE technical guide (State Office of Michigan).
VanKoppen, B. (Barbara), 1998. More jobs per drop: targeting irrigation to poor women and men. Doctoral thesis Wageningen Agricultural University, 187 p., ISBN 90-5485-910-5.
VanLoon, E. (Emiel), 2002. Overland flow: interfacing models with measurements.
Doctoral thesis Wageningen Agricultural University, 171 p., ISBN 90-5808-558-9
VanPaassen, A. (Annemarie), 2004. Bridging the gap: computer model enhanced learning about natural resource management in Burkina Faso. Doctoral thesis Wageningen University, 219 p., ISBN 90-5808-961-4.
VanRheenen, T. (Teunis),1995. Farm household level optimal resource allocation: An explorative study in the limestone area of East Java, Ph.D. thesis, Wageningen Agricultural University, Wageningen, The Netherlands.
Veldkamp, A. and E.F. Lambin, 2001. Predicting land-use change. Agriculture, Ecosystems and Environment 85:1-6.
Vigiak, O. (Olga), 2005. Modelling spatial patterns of erosion in the West Usambara Mountains of Tanzania. Doctoral thesis Wageningen University, 176 p., ISBN 90-8504-169-4.
Vigiak O., S.J.E. van Dijck, E.E. van Loon and L. Stroosnijder, 2006. Matching hydrologic response to measured effective hydraulic conductivity. Hydrological Processes 20: 487-504.
Visser, S.M. (Saskia), 2004. Modelling nutrient losses by wind and water erosion in northern Burkina Faso. Doctoral thesis Wageningen University, 169 p., ISBN 90-5808-999-1.
Vrieling, A. (Anton), 2007. Predicting erosion from space. Doctoral thesis Wageningen University, 151 p., ISBN 978-90-8504-587-8.
Wesseling, J.G. (Jan), 2009. Soil physical data and modeling soil moisture flow. Doctoral thesis Wageningen, 179 p., ISBN 978-90-8585-308-4.
Youssef, F. (Feras), 2012. Effect of vegetation cover and transition on regional wind erosion in drylands. Doctoral thesis Wageningen
Zida, Z. (Zacharie), 2011. Long-term effects of conservation soil management in Saria, Burkina Faso, West Africa. Doctoral thesis Wageningen, 142 p., ISBN 978-90-8585-836-2
Zenebe Adimassu, 2013. Towards sustainable land management in the Central Rift Valley of Ethiopia: Exploring the potential of co-investments. Doctoral thesis Wageningen

Zougmore, R. (Robert), 2003. Integrated water and nutrient management for sorghum production in semi-arid Burkina Faso. Doctoral thesis Wageningen University, 205 p., ISBN 90-5808-906-1.