Chapter one

Forest Management under Climate Change

Forestry and Forestry Research in South Africa

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Abstract

Forestry in South Africa is an important part of the economy and contributes to many livelihoods, particularly in the poor rural areas. However, the sector faces many challenges. One prominent challenge is definitely global change which will impact on both growth conditions and on the socio-economic boundary conditions. The following text should serve as a brief introduction to growth conditions, challenges and the institutionalised forest research in South Africa. It is not meant to be exhaustive and can only provide a snapshot in a highly dynamic sector which has shown its ability to change and adapt with a surprising speed worldwide to keep up with the changes in technology and society in order to provide a sustainable resource to the people.

1. Forest ecosystems and Forestry in South Africa

1.1 Natural conditions for forest growth in South Africa

South Africa's land area is with 1.22 million km^2 about 3.4 times the land area of Germany. South Africa stretches in latitude from south 22° to 34° (This would encompass a region from central Libya to southern Italy mirrored to the northern hemisphere at a comparable longitude. To exemplify the countries' longitudinal extension: crossing South Africa from Cape Town to the Kruger National Park is about 1850 km or the distance from Freiburg im Breisgau (Germany) to Minsk (Belarus).

The population density of South Africa is low with 41 / km^2 (e.g. Germany 229 / km^2) and concentrates along the eastern seaboard and in a few cities in South Africa's interior. The South African landscape, climate and vegetation are strongly influenced by relief: the country has a flat, narrow coastal seaboard, pronounced escarpment zones and a very large interior plateau area at altitudes greater than 1000m above sea level. Situated between Atlantic and Indian Ocean the country receives a cold influence from the Antarctic Benguela stream along the Westcoast and a warm influence from the Indian Ocean, causing a complex interaction of weather influencing phenomena. The El Niño/La Niña-Southern Oscillation (ENSO) has an substantial influence on the country's climate with El Niño-related drought risks in the summer season from October to March (Richard et al. 2000, 2001).

The diverse morphology and complex climatic conditions shaped a wide spectrum of edaphic and climatic sub-regions with a wide variety of growing conditions for plants. Large parts of the country falls into warm temperate and subtropical climate classifications. Vast areas of the country's northwest are dominated by arid conditions that do not permit tree growth without irrigation. The north-eastern regions receive the bulk of their precipitation in the summer growing period, while the south-western Cape regions have a Mediterranean climate with peak precipitation in winter. The coastal areas in the Southern Cape around Knysna show a small seasonality in precipitation and receive rainfall all over the year. Not only the precipitation seasonality varies across the country but also the total amount of precipitation (Figure 1) leaving only a small proportion of the land area suitable for agriculture and forestry.

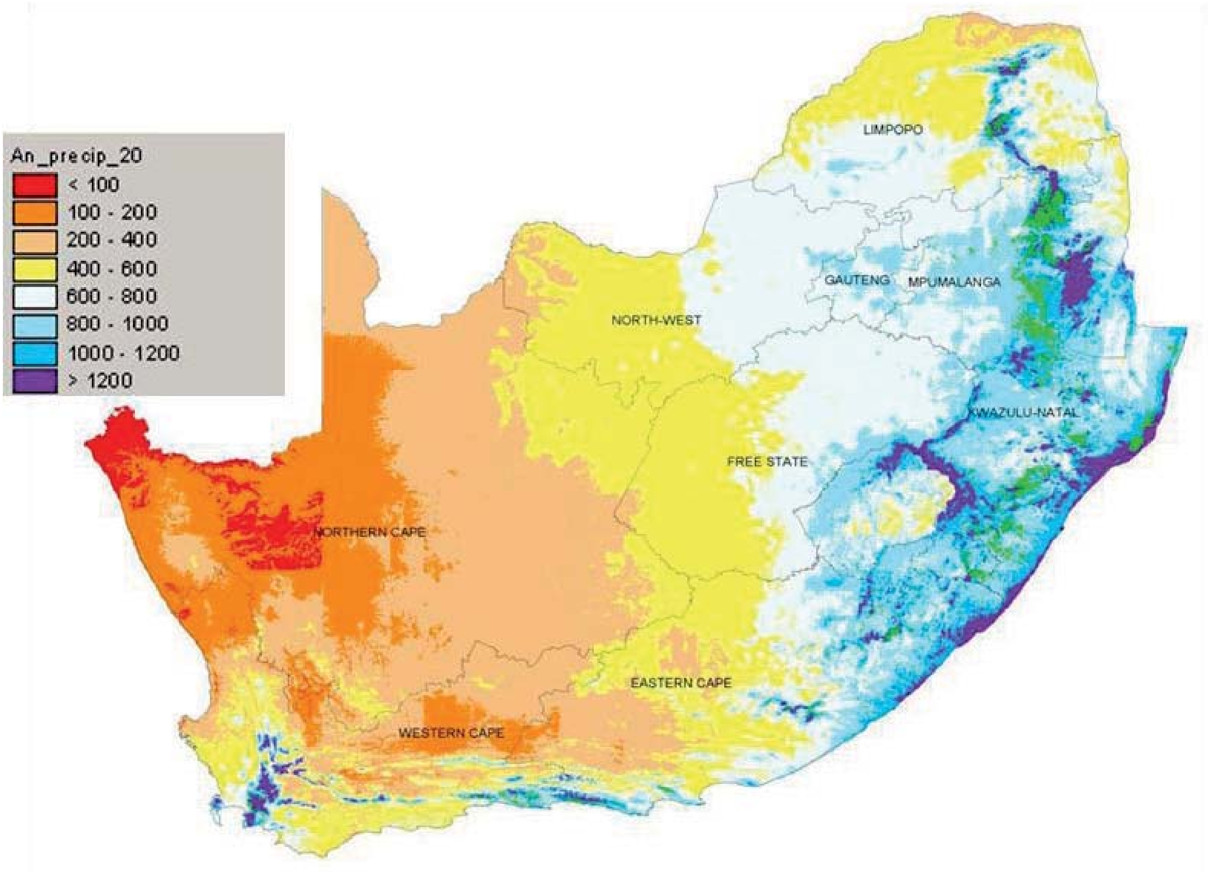

Figure 1. *Map showing the mean annual precipitation of South Africa (Schulze et al. 2008).*

1.2 Forests and tree dominated ecosystems

South Africa's main biomes are the savannas and woodlands in the northern and North-eastern part of the country, extended grasslands in the central plateau (Highveld), the Succulent Karoo and Nama Karoo are large semi desert areas in the North-western part, with the Fynbos, a Protea-dominated shrubland biome, occupying the South-western part of South Africa. Smaller areas along the coast line and at mountain slopes are occupied by thicket and Afrotemperate forests (Figures 2 to 5).

Figure 2. *Border between a pine plantation and Fynbos (© B du Toit).*

Figure 3. *Afrotemperate forest adjacent to Fynbos in the Southern Cape (© B du Toit).*

Figure 4. *Themeda grass land and a eucalypt plantation in Kwa-Zulu-Natal (© B du Toit).*

Figure 5. *Savannah, northern Kwa-Zulu Natal (© B du Toit).*

South Africa's forest resources encompass woodlands/savannahs which cover about one third of the country's land area (Willis et al. 2002), indigenous forests cover 0.5 % (estimated 504 803 ha, acc. Berliner & Benn 2004 ex. DWAF 2005) of the land surface and commercial plantations 1.1 % (1.2 million hectares).

1.3 Commercial forestry in South Africa

Natural forests are rather limited in area and productivity and most of them are protected. In the Southern Cape, where the biggest closed Afrotemperate forests are found, only a small area is used for timber production. The applied production system is a senility harvesting, where only trees are felled which have a high probability to die by natural circumstances in the next 10 years (Seydack et al. 1995). Though indigenous forests, if managed as multipurpose forests, could contribute more to the livelihood of local communities (Obiri et al. 2002). South Africa's main timber resource comes from commercial plantations with selected genotypes and hybrids and intensive silviculture to maximise the production on the limited plantation area in order to meet the objective of a balanced import-export situation in timber and wood based products.

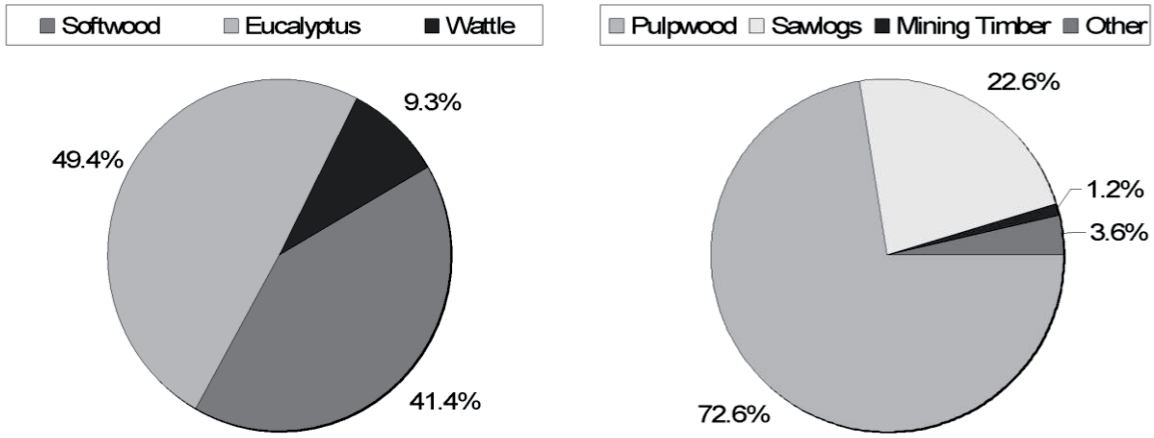

Figure 7. *Roundwood sales 2010 in South Afrika by species (left) and product (right) (Godsmark 2010).*

Commercial plantations in South Africa are mainly based on exotic eucalypt, pine and wattle (Australian *Acacia*) species (Figures 7 and 8).

The dominating production stream is pulp and paper amounting to 11 of 15 million total production. A good share of the pulp and paper production targets the Asian market. Table 1 illustrates the importance of pulpwood, sawlogs, poles, wood chips and mining timber. "In terms of changes in annual sales per product, sawlog sales showed the biggest gain - 536 000 t (18.4%) followed by pulpwood sales – 527 000 t (5.0%). Sales of other products dropped 52 000 t (-6.5%), the main reason being a 27.1% fall in mining timber sales" (Godsmark 2010).

Table 1. *Wood production from commercial plantations in South Africa in 2010 (Godsmark 2010).*

Products	Production (tons)
Pulpwood: Softwood	2 866 937
Pulpwood: Hardwood	8 219 532
Pulpwood total	11 086 469
Sawlogs: Softwood	3 154 673
Sawlogs: Hardwood	292 152
Sawlogs total	3 446 825
Poles: Softwood	105 584
Poles: Hardwood	222 522
Poles	328 106
Woodchips: Softwood	191 061
Mining: Timber:	190 383
Other: Hardwood	30 643
Grand Total	15 273 487

About 82.5 % of the sales are made by big corporates, 15.9 % by cooperatives and only 1.9 % by independent growers (Godsmark 2010).

Production cycles are comparatively short, ranging from an average of 9.7 in eucalypt pulpwood plantations to 10.2 years in wattle pulpwood plantations and 28.2 years in pine sawlog production circles with mean annual volume increments per hectare and year of of 21 (eucalypts), 13.4 (wattles) and 14.3 (pines).

1.4 Challenges for commercial forestry and forest research in South Africa[1]

South Africa's forestry and wood industry has made significant contributions to the sustainable supply of timber and fibre resources, employment and job creation, rural development and the provision of eco-system services over time, among many others. Notwithstanding this, the South African forest industry currently faces several additional major challenges, as follows: (1) international competitiveness in wood and fibre (cost and quality) delivery and an increasing demand for wood and fibre from a decreasing resource base both in South Africa and internationally; (2) socio-economic pressures; and one of the largest challenges (3) global change.

(1) International competitiveness

Commercial plantation forestry, as part of a global industry, is the cornerstone of sustainable timber and fibre production in South Africa. However, South Africa's role as a key player in international plantation forestry has been reduced in favour of international competitors such as Brazil, Chile, China, Australia and New Zealand. These countries have made significant investments in the research and development of their forestry and wood sectors. International developments and successes in tree breeding and site specific silviculture, and the inevitable mechanisation of harvesting operations have far outstripped national initiatives. Land suitable for forestry is also limited and this further constrains potential growth of the sector. Innovations must be made to create smart solutions adapted to South Africa. The Sawlog Strategy and Implementation Plan for South Africa (Ham et al. 2010) pointed out the need for (i) inventions to increase the productivity of the current resource, (ii) inventions to develop new and alternative resources and (iii) business inventions in order to optimise processes and develop new options.

(2) Socio-economic challenges in South Africa

Imminent changes to South African society include broad based black economic empowerment, land restitution and poverty reduction, particularly in rural areas. South Africa's forested land ownership is changing rapidly and will involve the redistribution of land to small owners, growers and communities who will require forestry expertise if they are to be empowered to use the land and resource to their and the countries benefit. This will change forestry

[1] Excerpt from Seifert et al. 2011: Position paper of forest and wood research

practice considerably and the full extent of its effect on productivity is unknown. In order to benefit the rural population, innovation is needed to transform the potentially detrimental fragmentation of forested land into a strong and integral part of South African forestry. A recent review of decision support systems (DSS) in South Africa (Seifert et al. in press) showed that current DSS systems are not geared towards the new challenges such as delineation, land restitution, theft and holistic land-management. While the existing DSS are productive and reliable in typical wood and fibre production oriented industry domains, they lack the capability to address land-use management holistically. This holistic viewpoint is essential to facilitate a regional optimisation of the land-use portfolio with regards to a full spectrum of ecosystem services, which are a precondition for sustainable regional planning.

(3) Global change

The key point of the most actual climate predictions are: (i) The temperature will increase, (ii) the mean annual precipitation will decrease in the West Cape and increase in the rest of the country. But the variability of precipitation is likely to increase across the country. The analysis on vulnerabilities of the forestry and wood sector to climatic change compiled for the Second National Report to the IPCC (Seifert et al. in press b) revealed a clear lack of knowledge with respect to the potential changes in growth and wood properties of commercial species. These changes include species adaptation to increased fire, hail, wind and snow risks as well as pathogens and the related expected damages/losses. Due to the uncertainty of current climate predictions, an “if-then” planning process based on scenario simulation is a first choice to facilitate a rapid response to actual climate change effects. Dynamic climate sensitive simulation tools for scenario planning are therefore required. Tree breeding for pathogen and drought resistant genotypes will be key factors for future success but these must also follow a holistic approach and take into account the resulting wood properties, product qualities and product marketability. The largely unused potential of climate change mitigation through optimised forestry operations and carbon sequestration can open up additional funding streams such as the REDD+ process. New inventory standards to determine forest area, growth and carbon sequestration should be established together with the neighbouring SADC countries.

2. Forest and tree related research in South Africa

2.1 Research institutions

Forest research in South Africa is conducted by academic institutions (universities), by industry financed research institutions and state owned research councils. Additionally, the bigger forest companies have established in-house research capacities with a focus on tree breeding and tree improvement.

Table 2. *Academic forest related research institutions and their research fields, sorted according to IUFRO divisions. Points indicate the capacity of the research group: ● 1 scientist, ●● 1-2 lead scientists plus MSc/PhD students, ●●● larger research group.*

	IUFRO Divisions							
	Silviculture	Eciophysiology & Genetics	Forest operations	Forest Assess ment modelling & management	Forest Products	Social, Policy, Economics & Information	Forest Health	Forest Environment
Stellen-bosch	●●	●●	●●	●●	●●●	●●	●	●
Pretoria						●●	●●●[1]	
KZN	●●●[2]	●●[2]			●●	●		
NMMU	●		●		●		●	●
UniVen	●	●						
Cape Town								●
Wits		●						

Units with large capacity associated with specific universities: [1] Forest and Agricultural Biotechnology Institute (FABI); [2] Institute for Commercial Forestry Research.

The academic institutions are Stellenbosch University, University of Pretoria, University of Kwa-Zulu-Natal, Nelson Mandela Metropolitan University (Saasveld), University of Venda, University of Cape Town and University of Witwatersrand. Their research focus in forestry is illustrated in Table 2. Only Stellenbosch University covers the full spectrum of forest related research.

The most important non academic institutions financed by industry are: The Institute for Commercial Forestry Research (ICFR), Pietermaritzburg with a focus on silviculture and genetic tree improvement, the TPCP tree pathology co-operative programme and the Forestry molecular biology co-operative programme (FMBC), both at the Forest and Agricultural Biotechnology Institute (FABI), linked with Pretoria University; the Division of Water, Environment and Forestry Technology (Environmentek) of the CSIR with a focus on tree improvement, hydrology, eco-physiology and forest products. Forestry related research on the biological control of invasive plants is conducted also at the Plant Protection Research Institute (PPRI) of the Agricultural Research Council (ARC).

2.2 The "Green Landscapes" project – extending the forestry perspective to an holistic landscape management[2]

Forestry has to recognise its role as an important land-use form in a context of a land-use portfolio. Tree based African landscapes share or compete with several other land-uses. These land-uses range from agriculture, in terms of food production; society, in terms of potentially impoverished rural and urban communities dependant on timber, non-timber products from natural forests and woodlands and arable land for their daily livelihood; and conservation and biodiversity needs. These land-uses not only mutually influence each other according to their spatial composition, but are subject to the influences of climatic change. Forests of the world have also been identified as major players in the mitigation of climate change and are found to strongly affect and contribute to the global climate. Yet in most cases sustainable management of this valuable resource, as mentioned above, is inadequate to entirely absent.

The objective of the "Green Landscapes" research programme is to contribute to the needs of society in developing spatial landscape based decision support tools and thus extend forestry management to a holistic land-use management. "Green Landscape Design" is a new concept of evidence based planning. The approach spatially integrates different land-use strategies, economic and social demands within the same region, including subsistence agriculture, biodiversity requirements and natural and commercial forestry in a trans-disciplinary approach based on systems thinking. Integrated land-use challenges will be met with an adapted landscape management approach that fulfils the following main criteria:

(1) Integrative and trans-disciplinary approach: The integration of the relevant variables requires significant collaboration between natural, engineering and social scientists since the problems of the respective disciplines interact strongly.
(2) Spatially explicit and regionally applicable: The position, extent and spatial arrangement of land-use forms create a specific pattern which affects the expected outcomes (products, eco-system services, etc.); thus, a rigorous and comprehensive spatial approach is imperative.
(3) Sensitive to climate change: Climatic change will play a major role in future land management because environmental and social conditions for land-use, production and work and many other landscape variables will change substantially. Long-term climatic trends as well as natural hazard prediction will have to be included in this scenario analysis.
(4) Adaptive planning: Planning must be flexible enough to choose the best land-use option in every situation every time. Compared to traditional long term static plans, a scenario supported by the Multiple Path approach offers a more suitable option. The idea is to determine the current situation, predict possible developments in the short

[2] "Green Landscapes" is a transdisciplinary project based at Stellenbosch University, financed by NRF/DST in the Global Change context.

and medium term and then update the planning effort in iterative steps. With this system, land-use in a region is constantly and continuously updated and optimised, ensuring a state where the most benefit for society without endangering environmental and economic sustainability, is derived.

(5) Data and policy driven: The use of reliable data and the constant alignment of management to relevant policies are important to prioritize different aspects of land-use and the possibility to react readily to change.

(6) Aggregation and suitability for technology transfer: The DSS and other models developed must be transferable to government/local authorities, practitioners, policy makers, land owners and other stakeholders for implementation at ground level in order to produce the desired outcomes of the research. The multitude of input variables with their complex interactions must be aggregated to a set of variables relevant for decision making.

A combination of GIS/RS integrated spatial eco-system models with decision support systems (DSS) are currently being practiced at the frontiers of scientific research worldwide (Denzer 2005, Fürst et al. 2010). However, no applicable or similar system is yet available for specific sub-Saharan African conditions. The scientific challenge is not so much the multi-criteria decision making model (MCDA) itself, which can be based on well-founded research, but rather the models necessary to produce the input for decision making and seamless integration into dynamic planning tools. These models must establish the ecologic, production oriented and socio-economic variables, which are used to feed the decision making process; and which inturn rely heavily on the spatial arrangement of land-use forms in interaction with the natural landscape.

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