

APPENDIX A: GEO-CLIMATIC CLASSIFICATION OF SOUTHERN AFRICA, SUMMARISED FROM SCHULZE 1965:313-322

Region M or Mediterranean

Rainfall: Mainly during May to September. Orographic and cyclonic in nature. Influenced by orographic features. 250mm in Breede River valley, 400-500mm on Cape Flats, 3000mm in some mountain kloofs.

Temperatures: Average maximums January 28°C, July 17°C; average minimum January 15°C, July 6°C.

Humidity: Average monthly humidity is 54% and is partly above the comfort zone in the winter and to a lesser degree in the summer.

Frost/snow: Average five occasions per year, usually in winter and early spring.

Winds: Summer winds mostly from southeast. Winter winds from northwest and bring rain. Winds are often strong to gale force.

Sunshine: 70% of possible in January, 60% of possible in July.

Notes: Climate similar to Mediterranean regions.

Region A or Garden Route

Rainfall: Receives rain throughout the year, although slightly more in autumn and spring. Orographic and cyclonic in nature. Thunderstorms and hail are infrequent. 1100mm at some coastal locations, 400mm on plains south of Riversdale.

Temperatures: Average maximums January 26°C, July 19°C; average minimums January 15°C, July 7°C.

Humidity: The average monthly humidity is high at 72%. Winter humidity is partly above comfortable but summer excess humidity is significant.

Frost/snow: Frost rare, snow on one to two occasions per year in the Langeberg and Outeniqua Mountains.

Winds: Can be strong along the coast in the spring, and in the interior berg/fohn winds blow one to three times per month in the summer increasing temperatures to around 38°C.

Sunshine: Average of 50% of the possible throughout the year.

Notes: Many prominent topographical features, beaches and great variety of plant types.

Region K or the Little and Great Karoo

Rainfall: Fairly evenly distributed throughout the year but with a double maximum common in March and November. Rain is almost always due to thunderstorms. Hail is infrequent. 250mm throughout most of reaches except some mountain areas receive up to 750mm.

Temperatures: Very large diurnal and annual variations in temperature are characteristic. Average maximums January 32°C, July 18°C; average minimums January 15°C, July 5°C. Temperatures of up to 44°C are not uncommon in the summer, and are caused by hot winds that blow off the high plateau.

Humidity: The average monthly humidity is around 68% and is usually within the comfort zone.

Frost/snow: Frost occurs from June to August but this period can be longer in extreme years. Snow occurs on the higher mountain reaches on about five occasions a year.

Winds: Winds are not strong but can cause temperatures to rise dramatically in the summer.

Sunshine: Around 70% of the possible.

Notes: Diurnal temperatures can range with 28°C or more, and despite the high summer temperatures winter nights can be chilly to cold.

Region W and SWAs or desert and poor steppe

Rainfall: Rainfall is unreliable and amounts to 250mm in the interior and decreases towards the west coast to 50mm or less. In the interior precipitation is in the summer and mainly in the form of conventional showers. Near the coast the rainfall is in the winter, sometimes the annual total falls in one heavy shower. Hail is uncommon in this region.

Temperatures: Temperatures are subject to great diurnal and seasonal variations. Average maximums January 35°C, July 18°C; average minimums January 17°C, July 3°C.

Humidity: Humidity is very low and usually below comfort index.

Frost/snow: Snow occurs around five times a year in the south near Sutherland but rapidly decreases to the north and west.

Winds: Dust storms similar to the "haboob" of Sudan sometimes occur in the Kalahari and hot easterly winds blow along the coastal belt during winter.

Sunshine: 80% or more of the possible throughout the year.

Notes: The west coast is often foggy due to the influence of the cold Benguela current. The highest temperatures in the country have been recorded in this region, with summer maxima of 46. Yet some of the coldest minimum temperatures in the country have also been recorded in this region near Sutherland.

Region Ss and Sn or southern and northern steppe

Rainfall: This region is on average semi-arid and receives from 250mm in the west to 500mm in the eastern reaches. Rain is in showers from October to March, the peak of which being near the end. Sometimes hail occurs in the early summer on a localised scale.

Temperatures: Average maximums January 30-33°C, July 17°C; average minimums January 15, °C July 0°C. Temperature ranges are slightly larger in the southern steppe region.

Humidity: The humidity of the southern steppe is around 55%, which is fair and within human comfort throughout the year. The northern steppe is only slightly dryer at 53%.

Frost/snow: Frost can be expected from May to September. Snow falls on around 5 occasions in the mountains of the southern region, notably the Snow, Winter- and Stormberg mountains.

Winds: They are usually north westerly with maximum speeds in the afternoon. During thunderstorms gusty south westerly winds are common. Dust storms also occur, although they are infrequent.

Sunshine: 70-80% of the possible, throughout the year.

Notes: Minimums of -11°C are possible in higher parts of the region.

Region SE or the south eastern coastal region

Rainfall: This region has a definite summer rainy season, which is at a maximum in March. Rain is usually of a showery nature and thunderstorms are relatively frequent. Hail is more frequent in the interior. The minimum rain falls in June. Rainfall varies from 500mm in the Fish River valley to 1250mm or more at Port St. Johns.

Temperatures: Average maximums January 28°C , July 21°C ; average minimums January 17°C , July 8°C .

Humidity: Average humidity is 70% and is high throughout the year but due to the temperature range this is usually not problematic.

Frost/snow: The frost period is only about one and a half months long, during July and August.

Winds: The winds are usually parallel to the coast, northeasterly and southwesterly. The former brings cloudless hazy skies and the latter is associated with cloudy weather and rain. Occasional gale force winds occur and on occasion during the late winter berg winds do occur.

Sunshine: During the winter the skies are clear about 70% of the time and in the summer around 50% of the time.

Region E or warm to hot and humid subtropical climate

Rainfall: The rainy period is usually in the summer from October to March with 120 to 140 rain days per year. The rain is usually due to instability showers with thunder on 40 to 50 occasions a year. The average varies from around 760mm in the northern interior to 1250mm on parts of the coast and the interior mountains.

Temperatures: Average maximums January 28°C, July 22°C; average minimums January 19°C, July 9°C.

Humidity: The average monthly humidity is 70% and in this region are problematic during the summer due to the high temperatures.

Frost/snow: frost only rarely occurs in some mountain valleys.

Winds: Northeasterly winds in the summer and southwesterly winds in the winter blow in equal proportions. The former is responsible for severely hot conditions and on rare occasions hot westerly winds blowing down from the mountains increase the temperature to around 38.

Sunshine: Summer cloudiness reduces the amount of sunshine to around 45% but during the winter it is around 70%.

Notes: This region has the smallest annual and diurnal temperature fluctuations and is one of the most humid in the country.

Region D or Drakensberg region

Rainfall: Most rain falls in the summer from November to March. Rainfall is mostly due to intense thunderstorms (60 to 90 a year) but mist and drizzle are common in the higher areas. The average annual amount varies from 680mm in the Tugela basin to 1900mm on some of the slopes of the mountains. Hail occurs around 6 times a year.

Temperatures: Average maximums January 27°C, July 19°C; average minimums January 15°C, July 3°C.

Humidity: The average humidity is seldom below 50%, and can be above comfort levels.

Frost/snow: The frost period is largely determined by the topography and can be from April to September. Snow is more frequent in the mountains than anywhere else in the country, around eight occasions a year.

Winds: Winds are southerly to northerly and northwesterly, the latter often being very strong.

Sunshine: This aspect varies from 50 to 60% in the summer and 70 to 80% in the winter.

Notes: This region has a climate similar to S and Se except that temperatures fluctuate more. It is the highest region in southern Africa.

Region L or Transvaal Lowveld

Rainfall: The rainy season lasts from November to March with a peak in January. Heavy thunderstorms and showers are most common. Against the mountains orographic rain and mist is more frequent. Amounts vary from 500mm to 700mm from north to south, but with a rapid increase along the escarpment to up to 2000mm a year. Hail only occurs about two times a year.

Temperatures: Average maximums January 30°C, July 23°C; average minimums January 18°C, July 8°C.

Humidity: The average monthly humidity is 47%, but summer humidity is high and sometimes uncomfortable, and below comfort in the winter.

Frost/snow: Frost is seldom experienced, usually in low-lying areas.

Winds: Winds are mainly from the south-southeast or north-northwest and sometimes reaches gale force along the mountains.

Sunshine: During the winter sunshine persists for around 75% of the possible time and in summer 50%.

Notes: The high temperatures and high general humidity can make this region oppressive at times, non the less it is one of the most popular tourist destinations in the country. Up to 300mm of rain in one day have been recorded in some parts of the region.

Region NT or the Northern Transvaal

Rainfall: Thunderstorms account for most of the rainfall, which varies from 380mm in the north to 700mm on parts of the Waterberg. The rainy season lasts from November to March. Rain is unreliable in this region and hail infrequent.

Temperatures: The climate is semi-arid and hot in the Limpopo valley but somewhat cooler and more humid in the mountainous areas. Average maximums January 32°C, July 22°C; average minimums January 18°C, July 4°C.

Humidity: The average monthly humidity is 59% and is not considered problematic throughout the year.

Frost/snow: Frost normally occurs from around June to August.

Winds: These are usually light to moderate and blow from the northeast except during weather changes or thunderstorms when they blow from the south.

Sunshine: This varies from 80% in the winter to 60% in the summer.

Notes: Summer days can be oppressive and some winter nights are decidedly chilly.

Region SWAn and B

Rainfall: rainfall is almost exclusively due to thunderstorms but hail is infrequent. Averages vary from 250mm to 600mm in the north. The rainy season is from around November to March.

Temperatures: Average maximums January 33°C, July 22°C; average minimums January 18°C, July 5°C. Low minimum temperatures of around -9°C can occur in the lower lying south of the region.

Humidity: The average humidity for this region is low, around 38%, and is below comfort for large periods of the year.

Frost/snow: The frost period is usually during June to August but decreases northward.

Winds: Winds are mainly light to moderate and from the northeastern sector.

Sunshine: Winter skies are almost cloudless with 90% of the possible sunshine and summers vary from 65 to 80%, cloudier conditions more common to the north.

Notes: The climate of the region is a composite of that of the three adjoining ones with an increase in humidity to the north.

Region H or the Highveld

Rainfall: Most of the rain is due to heavy thunderstorms that are accompanied by fierce lightning. Hail occurs around four to seven times a year. Amounts vary from 900mm in the east to 650mm in the west.

Temperatures: Average maximums January 27°C, July 17°C; average minimums January 13°C, July 0°C.

Humidity: The average monthly humidity is 56% and can be quite low during the winter.

Frost/snow: Frost can be expected from May to September in the northern parts of the region and for even longer periods in Lesotho.

Winds: On average winds are light but quite variable from location to location.

Sunshine: Sunshine is about 60% of the possible in summer and 80% in the winter.

Notes: Hail is most frequent in this zone, occasionally reaching the size of chicken eggs or tennis balls. They cause severe damage, as do the very rare tornadoes if they reach populated regions.

APPENDIX B: CLIMATIC CLASSIFICATION OF SOUTH AFRICA ACCORDING TO NAPIER (2000:9.1-9.11)

Sub-tropical plateau

Summer rainfall: 62mm in the west of the region to 375mm in the east.

Winter rainfall: Less than 62mm in the west to 125mm in the east.

Summer temperatures: 15°C in the west of the region to 27°C in the east.

Winter temperatures: 7°C in the west to 12°C in the east.

Prevailing winds: South in the summer and northeast in the winter.

Relative humidity: Less than 30%

Hours sunshine: More than 80%

General comment: Vegetation is sparse, with desert grasses and shrubs growing on sandy and stony surfaces. Conditions are very hot in summer, and in winter, cold at night especially at higher altitudes. Comparatively dry all year round, with greater precipitation in summer.

Desert

Summer rainfall: Less than 62mm.

Winter rainfall: Less than 62mm in the north to 250mm in the south.

January temperatures: 15°C at the coast to 25°C in the east.

July temperatures: Less than 7°C to 10°C.

Prevailing winds: South in the summer and north in the winter.

Relative humidity: Less than 30% inland to more than 70% at the coast.

Hours sunshine: 70-80%

General comment: With a cold sea current land adjacent is affected in temperature and humidity, with dramatic changes at high altitudes. Desert to semi-desert generates very high summer temperatures and in winter, cold night time readings. The high humidity at the coast is not uncomfortable because of lower temperatures from the sea. Fog patches are frequent.

Mediterranean

Summer rainfall: 62mm to 250mm in the south.

Winter rainfall: 250mm to more than 750mm at the Peninsula.

January temperatures: 20°C to 23°C.

July temperatures: 7°C to 10°C.

Prevailing winds: South to southeast in the summer and west to northwest in the winter.

Relative humidity: 50% inland to more than 70% at the coast.

Hours sunshine: Less than 60% in south to 80% in the north.

General comment: This zone is noted for its variety of fynbos and evergreen shrub. Winter rainfall gives the name "Mediterranean" and winds, especially from the southeast can be very strong, commonly reaching gale force. Prolonged cold wet spells mark the winter while hot persistent sun dominates the summer months.

Semi-arid plateau

Summer rainfall: 62mm in the East to 500mm in the west.

Winter rainfall: Less than 62mm in (East?) to 250mm in the west.

January temperatures: 20°C in South to 27°C in north.

July temperatures: Less than 7°C in the central plateau to 12°C in south and north.

Prevailing winds: North and south in the summer and northwest in the winter.

Relative humidity: Less than 30% in north to 50% in the south.

Hours sunshine: 60% in south to more than 80% in the north.

General comment: This region envelops most of the Little and Great Karroo and the sparse vegetation is mostly scrub and grass. Rainfall is low, with the greater proportion falling in the summer. Summer temperatures climb high during the days, and in the winter, nights are cold to very cold. Summer windstorms drive dust, being lifted by whirlwinds.

Temperate coast

Summer rainfall: 250mm to 500mm.

Winter rainfall: 250mm to 750mm at the coast.

January temperatures: 20°C to 23°C.

July temperatures: 12°C to 17°C.

Prevailing winds: south to west in the summer and west and east in the winter.

Relative humidity: 60% to more than 70%.

Hours sunshine: 60-80% inland.

General comment: This narrow strip is distinctive in having a year round rainfall. Vegetation is therefore profuse, with dense indigenous forest under preservation. The area is in close proximity to the Karroo and the climates are in strong contrast because of the dividing mountain ranges as related to wind directions. While relative humidity is high, temperatures are moderate (because of latitude and a moderating ocean) and comfort standards are not unpleasant.

Temperate eastern plateau

Summer rainfall: 125mm to 375mm.

Winter rainfall: 62mm to 250mm.

January temperatures: 20°C to 25°C.

July temperatures: 10°C to 15°C.

Prevailing winds: Northeasterly in the summer and northeasterly to northwesterly in the winter.

Relative humidity: 30-50% in the east.

Hours sunshine: 60-80% in west.

General comment: The Highveld is predominantly grassland with scattered trees in the wetter parts. Summers are warm to hot, with fairly dry air, relieved by thunderstorms generated from thermal air movement. Hail is not uncommon. Winter days are pleasantly sunny with clear cold to very cold nights. The Eastern portion of this region comprises the Drakensberg, which generate their own climatic patterns dependant upon the topography of the particular location. Differences from the rest of the region are mainly colder winter temperatures bringing occasional snow, hail and more pronounced thunderstorms.

Plateau slopes

Summer rainfall: 750mm to more than 1000mm.

Winter rainfall: 250mm to 375mm.

January temperatures: 20°C to 25°C.

July temperatures: 7°C to 12°C at lower altitudes.

Prevailing winds: South-Easterly in summer and South-West in the winter.

Relative humidity: 50% to 60%.

Hours sunshine: Less than 60%.

General comment: The foothills of the Drakensberg benefit from generous orographic rain brought from the warm Indian Ocean, resulting in rich grassland with trees in isolated patches. High rainfall gives longer protection from sun, but summer days are often warm to hot, relieved by thunderstorms as well as more prolonged rain spells, the former bringing hail periodically. Winter days are pleasant with nights cold to very cold.

Subtropical coast

Summer rainfall: 750mm to more than 1000mm.

Winter rainfall: 375mm to 750mm.

January temperatures: 20°C to 25°C.

July temperatures: 15°C to 20°C.

Prevailing winds: South to southwest and northeast.

Relative humidity: More than 70%.

Hours sunshine: Less than 60%.

General comment: This coastal strip is noted for its combination of medium to high summer temperatures with high relative humidity, resulting in very uncomfortable conditions. The Southern part of the region is relieved, with more frequent winds and lower temperatures. Winters are pleasantly warm, with nights cool but seldom cold. Summer nights are warm and humid, and the days, a challenge to architectural designers. Vegetation is mainly grass with subtropical bush land in patches, resulting from high rainfall. The nature of rain for the earlier part of the season is three or four consecutive days of moderate to mild precipitation, and the latter part, thunderstorms.

Subtropical low veld.

Summer rainfall: 750mm to 1000mm.

Winter rainfall: 500mm to more than 750mm.

January temperatures: 25°C to 27°C.

July temperatures: 15°C to 20°C in the north.

Prevailing winds: Easterly.

Relative humidity: More than 70%.

Hours sunshine: Less than 60%.

General comment: the description for this region is as that above, with more exaggerated temperatures and humidity but lower rainfall. Without mountains creating a boundary (as in the previous region), a large sector of low-lying land has lush vegetation, but with high humidity, shade provides little respite.

APPENDIX C: URBAN AND BUILDING RESPONSES TO GEO-CLIMATIC ZONES OF SOUTHERN AFRICA AS CLASSIFIED BY SCHULZE (1965), SUMMARISED FROM HOLM 1996:14-78

Mediterranean zone

Compact urban planning is useful for protection against strong prevailing winds (p14). Buildings should be orientated with longest side facing north/south creating an oblong plan form and should shield against summer living areas from southeasterly wind. Inhabited rooms should face north. Thermal mass is effective for approximately half the winter and is advantageous in summer, and should be concentrated in walls and floors. Cavity walls enhance thermal mass and provide damp protection (15). Summer sun should be screened and winter sun should penetrate. Single glazed equatorial windows should be 21% of the rooms serviced, reduced to 14% for double glazing. Natural ventilation is efficient for cooling (16), and direct evaporative cooling is sufficient for additional cooling where necessary (17).

Garden route

Compact urban planning with protection of outdoor living areas from winds from southeast and southwest. Oblong north-south building plan is preferred and inhabited rooms facing north (19). Thermal mass is effective for approximately half the winter and advantageous in the summer, concentrated in the walls and floor. Ample roof overhang and medium internal thermal mass is required. Summer sun should be screened and winter sun should penetrate, with equatorial windows 18% of floor area of rooms serviced (20). Natural breezes and ventilation should be sufficient to prevent overheating and may be aided by indirect evaporative cooling (21).

Semi-arid Karoo

Urban planning should be densely packed with mutual shading of buildings during summer. Streets to the shaded side of buildings should have deciduous trees. Evaporative cooling is

important. Building plan should be as compact as possible with minimal exposed areas (24). Plan form should be such that living spaces are on the north, to take advantage of winter solar gain, with shading in summer. Buffer spaces such as storage or garages should be placed on the east and west of the building. Large amounts of internal thermal mass are required to reduce diurnal temperature swings and massive external insulation should be provided. Dense concrete, brick and water are ideal insulation materials. Summer sun should be screened and winter sun should penetrate (25). 17% equatorial window to floor size is sufficient (26).

Desert steppe

Same as previous urban layout (compact etc) with large spreading trees. Typical plans are centred around a courtyard with small openings in exterior walls. External dimensions should be reduced with larger dimensions facing north and south (29). Inhabited rooms should face the courtyard with buffer rooms on the outside. Large thermal mass for interior and exterior surfaces is needed which alleviates half of the winter heating load and most of summer cooling load if combined with night ventilation. All surfaces should be lightly coloured, summer sun screened and winter sun allowed to penetrate (30). Shading of all exterior areas in summer is advised, with materials that have low thermal capacity. Equatorial glazing of 22% of floor area is sufficient for entire underheated period. Night ventilation is essential but ventilation during the day will have no positive effect! Openings should be closed during day in summer (31) and direct evaporative cooling is effective for half of overheated period. Indirect evaporative cooling is effective for entire period, and courtyard can be used for this purpose.

Northern steppe

Urban planning is of medium density with many shade trees in open spaces (34). Relatively compact plan forms are successful, with a well-insulated envelope and ground contact. External spaces should provide shade; deep verandas and pergolas are effective. Thermal mass in the form of massive floors and roofs and internal partitions can achieve this. Exterior surfaces should be light coloured (35). 21% of equatorial surfaces should be glazed, orientated towards the winter sun and shaded in the summer. Shade devices should have low thermal capacity. Night ventilation is effective throughout the over heated period if combined with

thermal mass. Stack ventilation or wind is effective for summer daytime cooling (36) and direct and indirect evaporative cooling is effective.

Southern steppe

Difficult to determine planning densities, due to contradictory requirements. Winter demands require a compact plan form with a well-insulated envelope and solar gain (39). External spaces should provide shade in summer for outdoor activities. Massive floors and internal partitions can aid in the reduction of diurnal temperature fluctuations. Exterior vegetation cover of deciduous plants is advised (40). Windows should be exposed for the winter sun and shaded during the summer and equatorial windows can provide most of the heat needed in the winter (41). Direct evaporative cooling is effective throughout the summer (42).

Southeastern coast

A loosely knit urban structure, that allows breezes to permeate is required, similarly the building plan form should include breezeways, combined with verandas (44). Buffer rooms should be placed on west of building, and thermal mass alleviates most of the underheated period cold. Lightweight roof insulation is needed if the roof is not massive. Winter sun should penetrate but summer sun should be shaded (45). Equatorial windows should amount to 10,6% of the floor space of these rooms. Evaporative cooling is ineffective, but ventilation can be used to assist the thermal mass effect during the overheated period (46).

Subtropical

Buildings should be free-standing and planned to assist air movement. Vegetation should not impede the movement of air. A narrow plan form with a single row of rooms allow for the most effective ventilation, with the north-south sides being the longest. Uninhabited rooms can be used as a buffer on the west side of the building with other rooms running the entire depth of the plan to facilitate cross ventilation (49). Lightweight construction is most appropriate for this climate, with thermal mass and ground contact being ineffective. However building on slopes allows good ventilation. Insulation on walls and roof is not necessary if they are totally shaded, with planting or a double roof construction. Light-coloured external surfaces ensure effective reflection and minimised heat gain. An equatorial window area of 16% is effective for the entire underheated period, but walls and openings

should be totally shaded. Deep verandas and broad eaves are also recommended (50). Adequate ventilation is necessary to remove excess heat and humidity. East- and west-facing walls should not have windows but the other facades must allow for the maximum penetration of wind. Wind should not pass over heated surfaces before passing through the building. Reflective (but not shiny) roofs and ventilated roof spaces are also effective.

Natal highlands

Open urban design required for summer conditions with covered sidewalks. Plan form should be oblong with an east-west footprint (54). High building mass will address above a third of the summer overheating problem but interior ventilation is required. Massive building materials for passive effects are required. Equatorial windows should be 20% of the floor area and is effective for the entire under heated period (55). Evaporative cooling is not effective and design that aids ventilation is needed (56).

Lowveld

Compact urban layout is needed to prevent against overheating during the summer, and row houses with internal courtyards are the most successful plan forms (59). The plan should allow for rooms that overheat quickly (like kitchen) or that are occupied often to ventilate to outside. Bedrooms may be lightweight to cool off faster. Thermal mass is only partially effective during summer and winter, whilst light-coloured exteriors and interiors are needed (60). Equatorial glazing of 19.4% is effective and daytime ventilation is effective to reduce overheating. Openings should be shaded during the day. Only indirect evaporative cooling is advised, as direct evaporative cooling will increase the high humidity (61).

Highveld

Relatively compact urban layout with protection against the high radiation levels is needed (64). Winter and summer requirements differ and therefore the plan form, and solar gain in the winter and adequate insulation is important. External shade spaces for summer activities are necessary, and a compact plan form is advisable. Thermal mass is also important, provided by correct materials, massive floors and walls and internal partitioning. Lightweight insulated roofs are also feasible. Light coloured reflective (but not shiny) materials to minimise solar gain is also important (65). Equatorial glazing should be 19,2% and should be so orientated that winter sun is allowed to penetrate (especially early mornings

- own note) but screened in the summer. Ventilation can alleviate overheating but may be unnecessary if thermal mass is employed. Summer night ventilation may compensate for insufficient mass (66). Direct evaporative cooling is effective throughout the summer and may be used to aid insufficient thermal mass (67).

Northern Transvaal

Canopies, arcades and trees are important and south facades should also be shaded in the summer due to high solar angle. Relatively compact plans and urban layout are also desirable as well as solar gain for the winter (69). External living spaces with shade should be provided. Buffer zones should be included on the west and south. Thermal massing is effective for half of the underheated and the whole overheated period. Massive floors, walls, roofs and partitions can provide this, although ceilings can be lightweight. External surfaces should be light in colour (70). Equatorial glazing should be 21,2% of the floor area and ventilation is effective during the summer. Night ventilation can compensate for insufficient mass during the summer. Direct evaporative ventilation is effective for the entire overheated period (71).

Namibia

Public fountains, trees, other vegetation and minimised paving improve climate. Large verandas and balconies create intermediate living areas. South facades are exposed to radiation during sunrise and sunset therefore living areas are best placed on the north (74). High mass, light colour and insulation required. 18,4% of equatorial floor area glazed. Night ventilation is useful (75). Evaporative cooling during summer and air movement can compensate for insufficient thermal mass (76).

APPENDIX D: CLIMATIC CLASSIFICATION OF SOUTH AFRICA ACCORDING TO KRUGER (13-11-2003)

Table III. Savanna-type Climatic Regions

Region	Climatic properties	Locality	Vegetation	Economic Uses
1. Northern Arid Bushveld	Lower than average (300–500 mm p.a.) and somewhat erratic precipitation for the Savanna type regions, with semi-arid and hot conditions in the Limpopo and Olifants River basins. Rainy season lasts from about Nov to Mar, with the peak falling in Jan. Winds are light to moderate and blow mostly from the northeastern sector. Almost frost free.	Northern and northwestern parts of the Northern Province.	Dominated by stunted shrubby growth with mostly dense Mopane <i>Colophospermum mopane</i> , with e.g. Acacia <i>Acacia nigrescens</i> and Boabab <i>Adansonia digitata</i> , White Seringa <i>Kirkia acuminata</i> , Stem Fruit <i>Englerophytum magalismontanum</i> . Grasslayer includes Redgrass <i>Themeda triandra</i> , Common Nine-awn grass <i>Enneapogon cenchroides</i> , Guinea Grass <i>Panicum maximum</i> and Tassel Three-awn <i>Aristida congesta</i> .	Ecotourism, cattle and game farming, subtropical fruit and vegetables (mainly through irrigation).
2. Central Bushveld	Similar to region 1 but decidedly wetter (500–750 mm p.a.) and somewhat cooler. Frost occurs more often.	Parts of Gauteng, North-West and Northern Province.	Tree species include African Beechwood <i>Faurea saligna</i> , Acacia, Buffalo Thorn <i>Ziziphus mucronata</i> . Shrublayer is moderately developed with e.g. Sandpaper Raisin <i>Grewia flavescens</i> , Peeling Plane <i>Ochna pulchra</i> and Blue Guarri <i>Euclea crispa</i> . Grasslayer well developed with e.g. Wire Grass <i>Elionurus muticus</i> , Turf Grass <i>Ischaemum afrum</i> , Fingergrass <i>Digitaria eriantha</i> and Common Russet Grass <i>Loudetia simplex</i> .	Ecotourism, cattle and game farming, wheat, maize, sunflowers.
3. Lowveld Bushveld	Moderate summer precipitation (500–700 mm p.a.) with maximum in Jan, with warm to hot temperatures. Humidity is fairly high, with summer days uncomfortable. The region is virtually frost-free. Sunshine duration during summer is below average for the Savanna climates.	Parts of Eastern Mpumalanga and Northern Province, extending into KwaZulu-Natal.	Tree species mainly Lebombo Ironwood <i>Androstachys johnsonii</i> , Red Bushwillow <i>Combretum apiculatum</i> , Acacia, Marula <i>Sclerocarya birrea</i> . Grasslayer moderately developed with e.g. Redgrass <i>Themeda triandra</i> , Annual Redtop <i>Brachiaria xantholeuca</i> and Common Nine-awn grass <i>Enneapogon cenchroides</i> . Dense bush on the uplands, where shrub- and grass layers are poorly developed.	Game, cattle and goat farming, subtropical fruit and vegetables (through irrigation), sugarcane, ecotourism.

Region	Climatic properties	Locality	Vegetation	Economic Uses
4. Southeastern Thornveld	Late summer precipitation (450–700 mm p.a. but can be much higher in isolated areas due to topography) with maximum in Mar. Below average temperatures while occasional snow can occur over the mountainous areas. The period which frost can be expected lasts from about May to Sep. Winds are usually northwesterly, although cold snaps during winter are accompanied by unpleasant cold southerly to south-westerly winds.	Central area of Eastern Cape Province.	Mainly bushveld with <i>Acacia</i> , but more grassland further inland with e.g. Redgrass <i>Themeda triandra</i> .	Cattle, sheep and goats.
5. Lowveld Mountain Bushveld	Due to its locality on the slopes of the Drakensberg, rainfall (with max in Jan) is high due to orography and can reach figures of 2000 mm in isolated areas. Patches of forest are therefore also present in this region. Although the incidence of fog is about 23 days per annum, it varies substantially from one area to another. Sunshine duration during summer is about 50% of the possible.	Eastern slopes of Drakensberg from Northern Province, through Mpumalanga into Swaziland.	Open tree savanna with e.g. Silver Clusterleaf <i>Terminalia sericea</i> , Bushwillow <i>Combretum collinum</i> and <i>Acacia</i> . Shrubs e.g. Sickle Bush <i>Dichrostachys cinerea</i> . Grass is tall and dense with e.g. Yellow Thatching Grass <i>Hyperthelia dissoluta</i> .	Cattle and game farming, subtropical fruit, forestry, ecotourism
6. Eastern Coastal Bushveld	Wet and humid, with the avg. annual precipitation reaching about 1400 mm at the coast, peaking in Jan or Feb. Winds are mainly north-easterly or south-westerly, especially close to the coast. Sunshine during the summer is below average with about 45% of the possible.	East coast westwards to the lower slopes of the Drakensberg in KwaZulu-Natal.	Forest patches at the coast with e.g. Forest Iron Plum <i>Drypetes gerrardii</i> , Uzimbeet <i>Millettia grandis</i> and White Ironwood <i>Vepris lanceolata</i> . Closer to seashore evergreen thicket occurs. Grasses include Ngongoni Bristlegrass <i>Aristida junciformis</i> . In swampy locations palms are prominent. Inland <i>Acacia</i> and Ngongoni Bristlegrass <i>Aristida junciformis</i> dominate. In valleys valley thicket occurs, forests in the more sheltered valleys and slopes.	Sugar and timber, cattle grazing.
7. KwaZulu-Natal Central Bushveld	Similar to region 6, although the precipitation is lower (700–900 mm p.a.) and the temperatures fluctuate more due to altitude and distance from the coast. Depending on topography, the period of possible frost can last from 90 - 150 days from Apr to Sep. Winds are mainly southerly and northerly to north-westerly, the latter often very strong in autumn. Sunshine duration varies from 50 - 60% of the possible in summer.	Northern KwaZulu-Natal.	Open savannah with <i>Acacia</i> . Variable grass layer with Common Thatchgrass <i>Hyparrhenia hirta</i> and Hairy Tridentgrass <i>Tristachya leucothrix</i> dominating. Northwards a mix of scrub and savanna, with trees e.g. <i>Acacia</i> and Red Bushwillow <i>Combretum apiculatum</i> . Also grass species like Redgrass <i>Themeda triandra</i> and Spreading Pricklegrass <i>Aristida congesta</i> .	Cattle and game farming, sugarcane, subtropical fruit, forestry

Table III. Savanna-type Climatic Regions (continued)

Region	Climatic properties	Locality	Vegetation	Economic Uses
8. Kalahari Bushveld	Rainfall varies from about 200 mm in the west to a maximum of about 450 mm p. a. at its eastern border. The rainfall season has its maximum during Jan and Feb in the central and eastern parts but Mar in the west, where it is very erratic. Temperatures are very extreme with about 3 months during summer with average max temperatures above 30 and one month during the year where the minimum drops below freezing. Sunshine duration is about 80% of the maximum, even during the rainy season in summer. Winds are usually north-westerly. Occasional cold snaps are accompanied by southerly winds that can last for a day or two.	Northern parts of the Northern Cape and northwestern part of North-West.	Sparsely scattered trees of the <i>Acacia</i> type as well as e.g. Sheperd's Tree <i>Boscia albitrunca</i> . Shrub- and grass layers poor to moderately developed depending on rainfall. Species include e.g. Honeythorn <i>Lycium bosciifolium</i> , Kalahari Currant <i>Rhus tenuinervis</i> , Sour Bushmangrass <i>Schmidtia kalahariensis</i> and Kalahari Coach <i>Stipagrostis amabilis</i> . Further south trees give way to a well-developed grass layer, but in the east a typical bushveld character exists.	Livestock and game farming, ecotourism
9. Kalahari Hardveld Bushveld	This region is similar to region 8, but because of the somewhat higher elevation, the rainfall is higher and less erratic and ranges from 350–500 mm. Hail is also possible. Northerly winds tend to dominate.	Northeast Northern Cape, southwestern part of North-West and small part of Western Free State.	Tree layer poorly developed with e.g. Wild Olive <i>Olea europaea</i> and Black Thorn <i>Acacia mellifera</i> . Shrubs e.g. Camphor Tree <i>Tarchonanthus camphoratus</i> and Kunibush <i>Rhus undulata</i> . Grass layer moderately developed with e.g. Broadleaf Bluestem <i>Diheteropogon amplexans</i> and Copperwire <i>Aristida diffusa</i> . Eastward trees become more abundant e.g. <i>Acacia</i> types; tall grass species e.g. Redgrass <i>Themeda triandra</i> are abundant.	Livestock and game farming

Table IV. Grassland Type Climatic Regions

Region	Climatic properties	Locality	Vegetation	Economic Uses
10. Dry Highveld Grassland	Precipitation ranges from about 450 mm in the west to about 700 mm at its northern border. The rainy season reaches its maximum during Dec and Jan in the north, but Feb to Mar in the west and south. Over the high lying areas snow is possible during the winter months. Winds are highly variable but tend to be more from the north to north-east.	Parts of eastern North-West southwards into central and western Free State.	Vegetation consists of mainly grassland with some trees along watercourses. Grass species include Giant Speargrass <i>Trachypogon spicatus</i> , Broadleaf Bluestem <i>Diheteropogon amplexans</i> , Caterpillar Grass <i>Harpochloa falx</i> , White Buffalograss <i>Panicum coloratum</i> , Weeping Lovegrass <i>Eragrostis curvula</i> , Redgrass <i>Themeda triandra</i> . Woody vegetation such as <i>Acacia</i> and Mountain Karee <i>Rhus leptodictya</i> also occur. West of Bloemfontein, Karoo elements are present, but this should not necessarily be considered as encroachment.	Maize production, cattle and sheep.
11. Moist Highveld Grassland	Similar to region 10, but cooler and wetter due to higher elevation and position relative to rain-bearing systems. Precipitation, which ranges from 600-800 mm p.a., has its maximum during Dec and Jan, but Feb in the south. Frost occurs regularly during the winter months and ranges, from available data, from about 30 days in the Mpumalanga area to about 70 days in the southern Free State. Winds are highly variable but easterly and westerly winds are more prevalent. Closer to the mountain ranges the incidence of frost is probably even higher. Over the higher lying areas snow is not an unusual event.	Parts of Gauteng and Mpumalanga southwards into eastern and southeastern Free State.	Grass species include Redgrass <i>Themeda triandra</i> , Three-awn Rolling Grass <i>Aristida bipartita</i> , Fan Lovegrass <i>Eragrostis plana</i> , Broom Needlegrass <i>Triaraphis andropogonoides</i> , Bushveld Turpentinegrass <i>Cymbopogon plurinodis</i> . Forbs include Fishbean <i>Tephrosia semiglabra</i> , Wild Petunia <i>Ipomoea obscura</i> , and Bladderweed <i>Hibiscus trionum</i> . Invasion of Karoo bushes e.g. Bitterkaroo <i>Pentzia globosa</i> may occur in some areas. Some dense woody thickets e.g. Oldwood <i>Leucosidea sericea</i> occur in places in the north.	Maize, Cattle and sheep, crop production, dairy farming, ecotourism.
12. Eastern Grassland	A more moderate climate than region 11, with less frost during winter due to its lower elevation. Rainfall is high and ranges from 650 mm to more than 1000 mm closer to the Drakensberg. Winds tend to be from the northeastern or southwestern sector. A total of 100–150 rainy days are experienced. Intense thunderstorms occur frequently, but less so closer to the coast. Snow is possible over the higher lying areas.	Southern KwaZulu-Natal and eastern Eastern Cape interiors.	Grass species include Redgrass <i>Themeda triandra</i> , Speargrass <i>Heteropogon contortus</i> , Wire Grass <i>Elionurus</i> . Forbs e.g. Spiky Cucumber <i>Cucumis zeyheri</i> . Trees and shrubs e.g. Common Spikethorn <i>Maytenus heterophylla</i> occur in sheltered sites.	Grazing, crop production, forestry, ecotourism.

Table IV. Grassland Type Climatic Regions (continued)

Region	Climatic properties	Locality	Vegetation	Economic Uses
13. South-east Coast Grassland	A wet climate (1000 to more than 1250 mm but somewhat drier in the south) with moderate temperatures. The rainfall season peak during the early rain months from Oct to Dec. Winds, that tend to be from the northeastern or southwestern sectors, are sometimes very high.	Eastern coastal strip of the Eastern Cape.	Grass species include Redgrass <i>Themeda triandra</i> and Hairy Tridentgrass <i>Tristachya leucothrix</i> . Although the vegetation consists of mainly grass, Fynbos patches are common as well as shrubs e.g. Blombos <i>Metalasia muricata</i> and Gonnabos <i>Passerina rigida</i> .	Grazing, tourism.
14. Eastern Mountain Grassland	Rainfall varies a lot over short distances due to topography (500 mm in the valleys and lee sides of the mountains and some places exceeding 2000 mm p.a. on the eastern slopes), and occurs mainly during summer, peaking between Dec – Feb. Temperatures tend to be cool, especially in the south. Also due to the topography, the directions of winds tend to vary substantially from one area to another. The climate is extreme with frost and fog occurring frequently, while snow is also possible in most parts.	High-altitude mountainous area (mainly the Drakensberg Range) stretching from the Northern Province southwards into the Eastern Cape.	Grasses include Common Russetgrass <i>Loudetia simplex</i> , Giant Speargrass <i>Trachypogon spicatus</i> , Wiregrass <i>Elionurus muticus</i> , Common Thatchgrass <i>Hyparrhenia hirta</i> , Drakensberg Danthonia <i>Merxmuellera drakensbergensis</i> , Goat Fescue <i>Festuca caprina</i> . Forest-related bush clumps with woody species e.g. Bastard Lemonwood <i>Psychotria capensis</i> and Broadleaf Waxberry <i>Myrica pilulifera</i> occur in places, especially in the north. Lilies (Lilaceae), Irises (Iridaceae), Daisies (Asteraceae), Mints (Lamiaceae) and Orchids (Orchidaceae) occur. Many forest patches occur. Dwarf shrubs e.g. Ghombos <i>Felicia filifolia</i> and Anchor-karoo <i>Pentzia incana</i> may occur in drier or overgrazed patches.	Forestry, grazing, ecotourism, and most importantly a water catchment area.
15. Alpine Heathland	Similar to region 14, but decidedly colder and drier due to height above sea level.	High altitude area of the Drakensberg range with altitude above 2800 – 3000 m	Similar to region 14 but species that can withstand altitudinal drought become more common. These include the abundant shrub <i>Helichrysum trilineatum</i> and the more localized <i>Erica dominans</i> . <i>Merxmuellera macowanii</i> grass tends to be prominent in this area. <i>Chrysocoma ciliata</i> shrubs are also common, especially in disturbed areas.	Grazing, tourism, and water catchment.

Table V. Karoo Type Climatic Regions

Region	Climatic properties	Locality	Vegetation	Economic Uses
16. Great and Upper Karoo	A dry (less than 100 mm in the northwest – 300 mm in the east), extreme climate with high temperatures during summer but very cold in the winter. Autumn rainfall, peaking in March, tends to be highly unpredictable and occurs in patches. This tends to be in the form of isolated thunderstorms but rainfall of a cyclonic nature can also occur in the southwest. During summer winds from the southwest are more prevalent compared to winter when winds from the north tend to dominate.	Central Cape. Northern	Annuals e.g. Brakspekbos <i>Zygophyllum simplex</i> and non-succulent shrubs e.g. Thorny Kapokbush <i>Erioccephalus spinescens</i> , Silverkaroo <i>Plinthus karoicus</i> and Perdekaroo <i>Rosenia humilis</i> . After good rains perennial grasses become more visible e.g. Tassel Bristlegrass <i>Aristida congesta</i> and Lehman's Lovegrass <i>Eragrostis lehmanniana</i> . Among the steep slopes of the Orange River Quiver Tree <i>Aloe dichotoma</i> , Bushman Poison Tree <i>Euphorbia avasmontana</i> and Aggenys Milkbush <i>Euphorbia gregaria</i> occur. Trees include <i>Acacia</i> , Threethorn <i>Rhigozum trichotomum</i> and Sheperd's Tree <i>Boscia albitrunca</i> .	Small-stock farming e.g. sheep and goats. Irrigation crops along Orange River e.g. cotton, lucerne and grapes.
17. Eastern Karoo	Similar to region 15, but decidedly wetter (300-500 mm p.a.). The late-summer to autumn rainfall season peaks from Feb – Mar.	Parts of western Free State, Northern Cape And Eastern Cape.	A complex mix of grass and shrubs depending on seasonal rainfall events. Shrubs include Bitterkaroo <i>Pentzia incana</i> and Kapokbush <i>Erioccephalus ericoides</i> . Grasses e.g. Redgrass <i>Themeda triandra</i> occur extensively after good rains. <i>Acacia</i> trees are common along dry river beds.	Small-stock farming e.g. sheep and goats. Irrigation along Orange River.
18. Little Karoo	Low rainfall (less than 200–300 mm p.a. but patches with higher rainfall exist due to topography), mainly in winter, of a cyclonic nature. It becomes more evenly distributed in the east.	Parts of the Western Cape interior.	Succulent species e.g. Thorn Vygie <i>Ruschia intricata</i> . Non-succulent shrubs e.g. Hairbush <i>Hirpicium integrifolium</i> and Bankruptbush <i>Pteronia pallens</i> . Low Trees e.g. Jacketplum <i>Pappea capensis</i> and Common Guarri <i>Euclea undulata</i> . Grasses are scarce.	Irrigation e.g. grapes, wheat, lucerne. Ostriches, small stock and cattle.
19. Western Karoo	Very dry (less than 100–200 mm p.a.) with extreme temperatures, which can become very cold during winter. Rainfall can be isolated thunderstorms or of a cyclonic nature. Winds are similar to region 20.	Western Cape and parts of the Northern Cape.	Low shrubs and small trees, e.g. the Quiver Tree <i>Aloe dichotoma</i> which dominates in the west, while plants in the Vygie family (Mesembryanthemaceae) are the dominant dwarf shrubs. Most plants depend on the cyclonic winter rains for moisture.	Small stock farming, tourism, irrigation e.g. wheat, oats and barley.

Region	Climatic properties	Locality	Vegetation	Economic Uses
20. West Coast	Very dry almost desert-like climate (especially in the north) with a high frequency of fog due to the cold Benguela ocean current. Rainfall period exclusive to Jun and Jul. Winds are mainly from the south, but quite variable during the winter months.	A strip along the west coast.	Low shrubs to medium-tall shrubs in the south occur e.g. Sage <i>Salvia lanceolata</i> and Tortoisebush <i>Zygophyllum morganii</i> . This vegetation is called the Strandveld.	Minerals, tourism, fish.

Table VI. Desert Type Climatic Regions

Region	Climatic properties	Locality	Vegetation	Economic Uses
21. Northwestern Desert	Annual rainfall is 50 mm or less. It receives more rain in the form of thunderstorms than cyclonic winter rain. The above, as well as the infrequent fog it receives from the sea, results in a true desert similar to the Namib in adjacent Namibia.	Extreme northwestern Northern Cape.	Mainly annual species as well as perennial types in the drainage channels and washes. The grass <i>Aristida parvula</i> is a good example of an annual species in this area.	Tourism.

Table VII. Fynbos Type Climatic Regions

Region	Climatic properties	Locality	Vegetation	Economic Uses
22. Southwestern Cape	Winter rainfall with very dry summers. The climate varies a lot from place to place due to the mountainous nature of the area. The climate can thus not really be considered homogeneous, except for the rainfall season and to a lesser extent the temperatures; which tend to be moderate, but can become high during summer. E.g. the rainfall varies from 250 mm at the west coast to 1400 mm on the slopes of Table Mountain. Winds from the north to north-west as well as from the south tend to dominate, but due to topography more inland this can also become more variable.	Southwestern Western Cape.	Numerous fynbos species in the more mountainous areas. Also Conebush <i>Leucadendron elimense</i> , Blombos <i>Metalasia muricata</i> , Elim Gonna <i>Passerina galpinii</i> lower down. On limestone Limestone Sugarbush <i>Protea obtusifolia</i> and Limestone Conebush <i>Leucadendron meridianum</i> and members of the Buchu Family (Rutaceae). On the sandy plains Ninepin Heath <i>Erica mammosa</i> , Starface <i>Phyllica cephalantha</i> and Sandveld Thatching Reed <i>Thamnochortus punctatus</i> dominate. Renosterbushes include Renosterbos <i>Elytropappus rhinocerotis</i> , Gumbush <i>Relhania genistifolia</i> , Acasia, Bitter Aloe <i>Aloe ferox</i> , Common Guarri <i>Euclea undulata</i> , Ashbush <i>Pteronia incana</i> , Wild Rosemary <i>Erioccephalus africanus</i> , Dune Teabush <i>Leysera gnaphalodes</i> . Grasses include Redgrass <i>Themeda triandra</i> and Cape Terpentinegrass <i>Cymbopogon marginatus</i> . Geophytes include Irises (Iridaceae) and Lilies (Liliaceae). Bush clumps occur with e.g. Wild Olive <i>Olea europaea</i> and Dune Taaibos <i>Rhus laevigata</i> . Wind-created cloud on the higher mountains in summer is important for many fynbos species.	Water catchment, sheep farming, wheat, vegetables, fruit, flowers, recreation, ecotourism.
23. Southern Cape	A moderate, all-year rainfall climate, with maxima in autumn and spring. Winds tend to blow from the northwestern and southeastern sectors in the west, from the west and east in the center of the area, and from the southwestern and northeastern sectors in the east (the directions coincide with the orientation of the coastline).	Southern Western Cape and Eastern Cape.	More or less the same as above but a high proportion of grasses exists, especially in the east, mainly Redgrass <i>Themeda triandra</i> , Velvet Signalgrass <i>Brachiaria serrata</i> and Ratstail Dropseed <i>Sporobolus africanus</i> .	The same as above, but including forestry

Table VIII. Forest Type Climatic Regions

Region	Climatic properties	Locality	Vegetation	Economic Uses
24. Southern Cape Forest	A moist area with high rainfall (800 to more than 1000 mm p.a.), having two maxima during the year, but peaking in October. Three to four months of rainy days are experienced. Temperatures are mild and frost is almost non-existent. The topography and its closeness to the coast, make the part of this region closer to the mountains prone to fog. George and Saasveld experience fog about 29 days p.a. Winds are mainly westerly or easterly.	Southern parts of Western Cape and Eastern Cape, between the sea and the Cape Fold Belt Mountains.	Although forests occur at several places in the east and south of South Africa, this is the only region where it forms a sizeable area for climatological purposes, solely occupied by it. Were it not for fires, forests would have occupied a larger area, but in this region it is protected by the sea and the Cape Fold Belt mountains. Trees dominate with e.g. Outeniqua Yellowwood <i>Podocarpus falcatus</i> and White Witchhazel <i>Trichocladus ellipticus</i> . Shrubs and climbers are common e.g. Common Spikethorn <i>Maytenus heterophylla</i> and Cat-thorn <i>Scutia myrtina</i> . Grasses, herbs and ferns occur in the undergrowth. As a consequence of substrate and soil moisture differences a significant part of the area is not covered with forest but with fynbos.	Tourism, forestry, firewood and water catchment.