Greenhouse Gas Assessment Biomass Industry Park

Transcontinental Biomass Partnership with Namibia

Dr. Felix Flesch

Institute for applied Material Flow Management

Namibia BIOMASS INDUSTRIAL PARK

Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER

IfaS Institut für angewandtes Stoffstrommanagement

german cooperation DEUTSCHE ZUSAMMENARBEIT

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Background

1) Namibia is facing a tremendous climate adaptation problem! Not a climate mitigation problem!

2) This is why Namibia needs new models to address the threat of bush encroachment. What are the alternatives?

   a) Namibia permits further encroachment to preserve the carbon sink.

   Result: No groundwater protection, No value addition (contrary increased losses), Biodiversity losses, **`Costly´ carbon capture**

   Risk: Total depletion of water tables irreversible change of savannah biome

   b) Namibia thins bush and satisfies local market demand for bush-based products.

   Comment: Both local material and energy demand falls below rate of spread. **High LCOE!** Thermodynamic low efficiency at local use can lead to higher carbon emissions then under export scenarios.

   c) Other off-takers establish large scale biomass strategies.

   Comment: Without proper consideration of environmental, social and value adding aspects.

Biomass partnership model – GHG Assessment

3) Biomass partnership model enters the **corridor between adaption and mitigation** with the option to safe more carbon per hectare and adapt by adding value (incl. all further expected positive site effects). BIP as starting point for entering into a rural bioeconomy.

Verification: The biomass partnership is a working **hypothesis** targeting at least REDDII requirements.

References: Decisive literature, expert interviews, site visits. Literature indicates feasibility as interviews do, however the partnership model and associated multifunctional land use system is new to Namibia and a BIP is first of its kind.

Evidence: There are uncertainties, ranges and estimates. **No claim** to have certainty about every facet beforehand. But this is the driver for the partnership. We appreciate upright and constructive dispute, knowledge transfer and data validation for sound and holistic examination.

Partnership: Establishes possibilities to protect and/or restore the threatened biome in the lean corridor of adaptation and mitigation.

System: Multifunctional land-use. Savanna grass restoration for a time! Continuous but alternating land-use, with bush-thinned open grass mosaics and controlled bush regrowth.

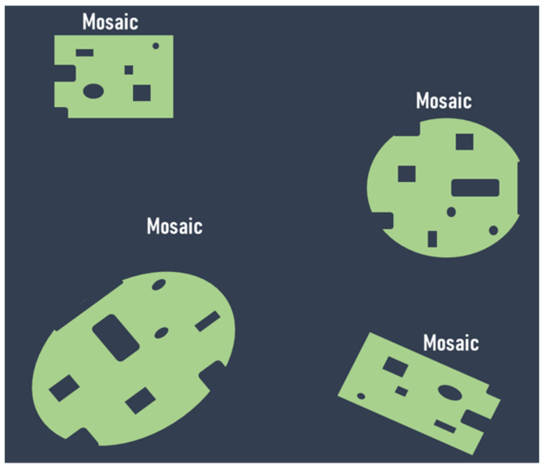
Airbag: **As long as extraction rate stays well under the rate of bush growth (15 Mio. t/a), the carbon sink will grow or at least remains stable.**

Multifunctional land-use system

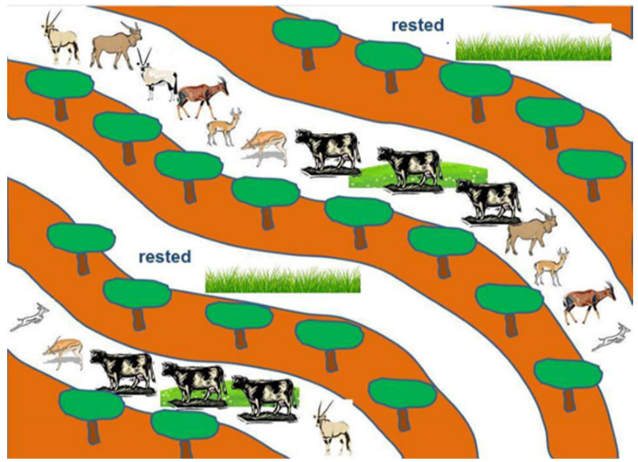
1) **No clear cutting!** Selective bush-thinning is applied following the regulation provided by MEFT! The objective is to re-establish a savanna landscape with patches of grass under tree canopy preferably in mosaic or swath form.
2) Within the first 6 years after bush-thinning, grass layer is managed locally adapted aftercare. Grass can serve as fodder for livestock and/or game or be used for material use purposes (e.g. grass paper).
3) Beginning of year six, regrowth of bush is permitted in a controlled manner (aftercare).

<u>Result:</u> Temporary Savanna per hectare! BIP throughput: 250,000t/a ≈ 21,000ha/a ≈ 6,800ha/a * 6a ≈ **41,000ha of shifting pastoralism** around the biomass hub.

Mosaic system



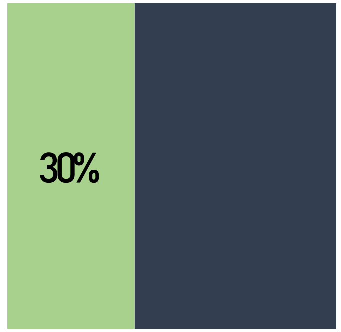
Swath system



Cockpit

Assumption

Projected harvest: 12 t_{DM}/ha (30% out of 1 ha)
Raw Material Use: 80% (9,6 $t_{pellets}$/ha) [CV 5 kWh/kg]
Carbon content: 47-50% (6 t_{carbon}/ha)



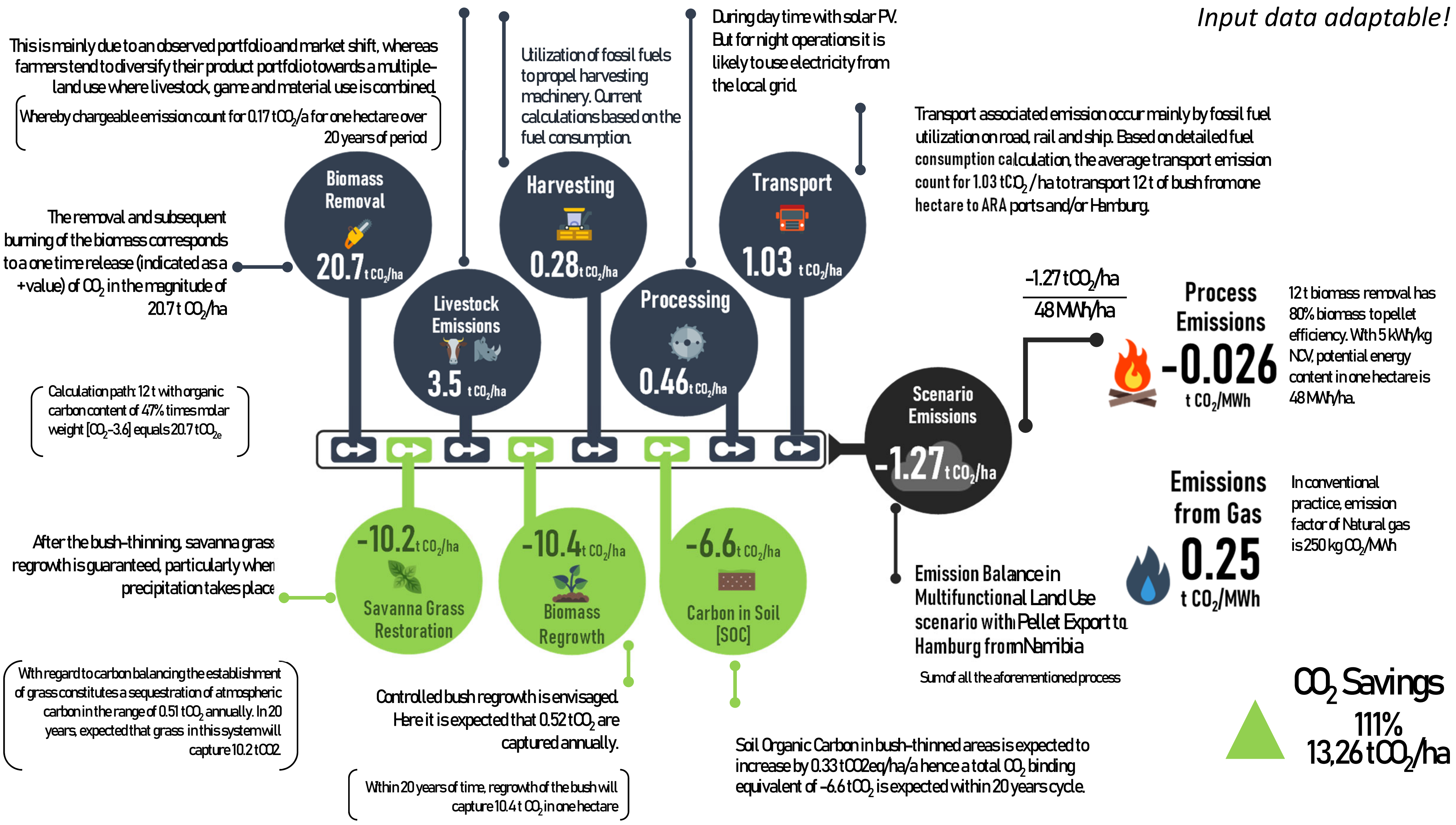
Overarching premises – conservative/cautious assumption

- Carbon balancing for **process related activities** (harvesting and processing) based on a BIP throughput of 250.000 t/a. Emissions accounted from fossil fuel use and electricity [50% renewable/50% grid SAPP] along the full value chain. This includes excavators, wheel loaders, tractors, loaders, chippers, sieving units, hammer mills, pellet presses, et cetera. Fuel emission values from IPCC, IEA and UBA.

- Carbon balancing for **transport related activities** based on fuel consumption. Data obtained from local service providers and international organizations!
  - Field to BIP – Truck or Tractor *(e.g. TWC)*
  - BIP to harbor – Rail *(TransNamib)*
  - Harbor to Europe – Ship *(e.g. IMO)*

- Carbon balancing for **livestock, grass and bush regrowth as well as SOC** obtained from Unique study but altered (conservative) for present model, coupled with literature, personal expert interviews and own calculations. First 6 years after harvesting for savanna grass restoration, material use and game (33% each) and SOC built-up. In 6^{th} year regrowth of bush.

Multi-functional land-use system with sound aftercare.



Input data adaptable!
This is mainly due to an observed portfolio and market shift, whereas farmers tend to diversify their product portfolio towards a multiple-land use where livestock, game and material use is combined.
Whereby chargeable emission count for 0.17 tCO_2/a for one hectare over 20 years of period
Utilization of fossil fuels to propel harvesting machinery. Current calculations based on the fuel consumption.
During day time with solar PV. But for night operations it is likely to use electricity from the local grid.
Transport associated emission occur mainly by fossil fuel utilization on road, rail and ship. Based on detailed fuel consumption calculation, the average transport emission count for 1.03 tCO_2 /ha to transport 12 t of bush from one hectare to ARA ports and/or Hamburg.
Biomass Removal
20.7 t CO_2/ha
Harvesting
0.28 t CO_2/ha
Transport
1.03 t CO_2/ha
Livestock Emissions
3.5 t CO_2/ha
Processing
0.46 t CO_2/ha
The removal and subsequent burning of the biomass corresponds to a one time release (indicated as a +value) of CO_2 in the magnitude of 20.7 t CO_2/ha
Calculation path: 12 t with organic carbon content of 47% times molar weight [CO_2-3.6] equals 20.7 tCO_{2e}
-1.27 tCO_2/ha
48 MWh/ha
Process Emissions
-0.026
t CO_2/MWh
12 t biomass removal has 80% biomass to pellet efficiency. With 5 kWh/kg NCV, potential energy content in one hectare is 48 MWh/ha.
Scenario Emissions
-1.27 t CO_2/ha
Emissions from Gas
0.25
t CO_2/MWh
In conventional practice, emission factor of Natural gas is 250 kg CO_2/MWh
-10.2 t CO_2/ha
Savanna Grass Restoration
-10.4 t CO_2/ha
Biomass Regrowth
-6.6 t CO_2/ha
Carbon in Soil [SOC]
After the bush-thinning, savanna grass regrowth is guaranteed, particularly when precipitation takes place
With regard to carbon balancing the establishment of grass constitutes a sequestration of atmospheric carbon in the range of 0.51 tCO_2 annually. In 20 years, expected that grass in this system will capture 10.2 tCO_2
Controlled bush regrowth is envisaged. Here it is expected that 0.52 tCO_2 are captured annually.
Within 20 years of time, regrowth of the bush will capture 10.4 t CO_2 in one hectare
Emission Balance in Multifunctional Land Use scenario with Pellet Export to Hamburg from Namibia
Sum of all the aforementioned process
Soil Organic Carbon in bush-thinned areas is expected to increase by 0.33 tCO_2eq/ha/a hence a total CO_2 binding equivalent of -6.6 tCO_2 is expected within 20 years cycle.
CO_2 Savings
111%
13,26 tCO_2/ha

Biomass removal, regrowth and livestock

1) Envisaged sustainable bush thinning (extraction) rate accounts for $12t_{DM}$/ha, which equals in average only 30% of the standing biomass. Thinning is done in swath or rather mosaic patterns. *(In line with MEFT, N-BiG, DAS, NNF, FSC)* With 47% of carbon, the removal of bush would release **20.7 tCO_2/ha**.

2) The part-time establishment and utilization of grass is part of the multifunctional land use system. In the first 6 years after first removal, grass growth is propagated. After the sixth year bush is allowed to regrow in controlled manner (Aftercare system). Sustainable average growth rate is leveled out at 20-25 years *(cp. Cunningham, P.; Zimmerman, I.)* meaning that bush will regrow in average during this timespan.

3) For sake of uncertainty we assumed only a 50% regrowth of bush, which is substantially pessimistic. **Most likely it is 15t/ha.** Future expert interviews will verify this. For the time being however, we take a conservative **10.4 tCO_2/ha** (0.69 tCO_2/ha/a) capture in a period of 20 years with 15 years of controlled regrowth.

4) Even if IPCC methodology does allocate livestock emissions into tier 3, debits for increased CH_4 emissions have been included into the balance. The assumed value has been borrowed from Unique and accounted for **3.5 tCO_2/ha** (0,17 tCO_{2eq}/ha/a), which is a third of the indicated value. This is based on tendencies to diversify the product portfolio from single cattle farming to game, cattle and material use of grass in BIPs with equal shares of 33%.

5) CO_2 balance of rain-fed beef is 10% better than feed-lot beef! This means for every feed lot cow which is substituted by a rain fed cow Namibia should get a 10% THG bonus!

Transport emission

In contrast to public awareness, transport emission play a substantial but not dominant role in the carbon balance. Based on total emissions, transport only **accounts for 3.97%,** with tendency to be further improved!

Namibia Real Data **Expected** Scenario			
	gCO_2/tkm	km	$kgCO_2/t$
Truck	33,6	100	3
Rail	22,7	600	14
See	6,9	10.000	69
SUM		→	**86**

Truck *(here data from TWC/Imperial)*		
Item	*Value*	*Unit*
Fuel consumption	38	l/100km
Load	30	t
CO_2 Emission →	**33,6**	**gCO_2/tkm**
	335,7	gCO_2/ha

Rail *(here data from TransNamib)*		
Item	*Value*	*Unit*
Fuel consumption	6	l/km
Distance	600	km
Load	700	t
Fuel on distance	3.600	l
Fuel on load	5,14	l/t
CO_2 Emission	13.629	gCO_2/t
→	**22,7**	**gCO_2/tkm**

Seefreight *(MACS Interview, IMO)*		
Item	*Value*	*Unit*
Bunker	1.100	t
	24	t
	1124	t
Density	0,991	kg/l
	1.113.884	l
CO_2 Factor Bunker	3,101	$kgCO_2/l$
Emission	3.454	tCO_2
	0,07	tCO_2/t
	0,83	tCO_2/ha
→	**6,9**	**gCO_2/tkm**

Local Use VS Export

Nota bene: In contrast to public awareness, local use of biomass in Namibia, aside from economic indices, can show lower (globally observed) GHG reduction potential than export to Europe and use in CHP plant! *Surely depending on the assumptions.*

Export to Germany					Use in Namibia			
Item	Value	Unit	Comment	Factor	Item	Value	Unit	Comment
Calorific Value Pellets	5	MWh/t			Calorific Value Pellets	5	MWh/t	
Output	200.000	t/a	Pellets		Output	200.000	t/a	Pellets
Harvesting	2.237	t/a	Diesel		Harvesting	2.237	t/a	Diesel
Processing	190	t/a	Diesel		Processing	190	t/a	Diesel
	18.900	MWh/a	Electricity			18.900	MWh/a	Electricity
Logistik	253	t/a	Diesel-Truck		Logistik	253	t/a	Diesel-Truck
	1.029	t/a	Diesel-Rail			514	t/a	Diesel-Rail
	2.250	t/a	Bunker-Shipment			0	t/a	Bunker-Shipment
Total	**78.487**	**MWh/a**			**Total**	**50.844**	**MWh/a**	
Calorific Value Output	**1.000.000**	**MWh/a**			**Calorific Value Output**	**1.000.000**	**MWh/a**	
CV Share	**7,85%**			**2,8%**	**CV Share**	**5,08%**		
Power Plant Efficiency	34%		Electricity		Power Plant Efficiency	32%	Electricity	
	50%		Heat			0%	Heat	
	84%		Total			32%	Total	
Net Electricity Use	340.000	MWh/a			Net Electricity Use	320.000	MWh/a	
Net Heat Use	500.000	MWh/a			Net Heat Use	0	MWh/a	
Total Energy Use	**840.000**	**MWh/a**		**2,63**	**Total Energy Use**	**320.000**	**MWh/a**	
Total less upstream	761.513	MWh/a		**2,83**	Total less upstream	269.156	MWh/a	
Grid Emission Factor	0,40	tCO_2/MWh	Electricity		Grid Emission Factor	0,87	tCO_2/MWh	Electricity
	0,30	tCO_2/MWh	Heat					
	0,70	tCO_2/MWh	Total	**0,81**				
Emission Savings	125.639	tCO_2/a	Electricity		Emission Savings	234.166	tCO_2/a	Electricity
	138.227	tCO_2/a	Heat					(IPPC-GEF-SAPP2020)
	263.866	**tCO_2/a**	**Total**	**1,13**		**234.166**	**tCO_2/a**	**Total**

Harvesting and processing emission

Harvesting and processing emissions account for approximately 3.5% of total expected emissions.

Here the partnership is essential, as innovation in machinery parks can reduce fuel and electricity consumption substantially.

Steady increase of renewable energy share and utilization of synergism in industrial zones (such as exhaust heat from charcoal retorts for pellet drying) can further decrease the GHG burden.

Harvesting

Item	*Value*	*Unit*
Capacity	250.000	t/a
Fuel Consumption	2.236.784	l/a
	5.927	tCO_2/a
	0,030	tCO_2/t
Output (here Pellets)	9,6	t/ha
	0,28	**tCO_2/ha**

Processing

Item	*Value*	*Unit*
Capacity	250.000	t/a
Electricity Process	2.400	MWh/a
Electricity Pellets	18.900	MWh/a
	10.437	tCO_2/a
Fuel	190.000	l/a
	503,5	tCO_2/a
SUM	10.941	tCO_2/a
	0,05	$tCO_2/t_{Pellets}$
Output (here Pellets)	9,6	t/ha
	0,53	**tCO_2/ha**

Savanna grass growth and SOC

	Item	Value	Unit	Source	Comment
Cockpit	Total Savanna Gras Mass	100	%		
	Above Ground Savanna Gras Mass	30	%	Chen et al (2003)	Literature range **trees** 14-86 (UG-AG) Ohlde et al (2019); Chen et al (2003)
	Under Ground Savanna Gras Mass	70	%		
	NPP Savanna Gras [Total]	10,0	t_{DM}/ha/a	Calculatory	
	NPP Savanna Gras [Above Ground]	**3,0**	**t_{DM}/ha/a**	Interviews with Rothauge, Schwalm and Lindeque (2020)	Range: 2-6 t_{DM}/ha/a
	NPP Savanna Gras [Under Ground]	7,0	t_{DM}/ha/a	Calculatory	
	Bush-thinning rate	33,3	%	MEFT, N-BiG, DAS	
	Carbon content Savanna Gras	48	$\%_{in\ DM}$		
Above Ground	NPP	1,0	t_{DM}/ha/a		
	Carbon in Savanna Gras	0,5	t/ha/a		
	CO_2 Storage in Savanna Gras	**1,76**	**tCO_2/ha/a**		
	Usage Cycle	6	a		
	CO_2 Storage in Savanna Gras over 20 years	0,53	tCO_2/ha/a		Match with Unique
Under Ground "SOC"	NPP	2,3	t_{DM}/ha/a		
	Carbon in Savanna Gras	1,1	t/ha/a		
	CO_2 Storage in Savanna Gras	**4,1**	**tCO_2/ha/a**		
	Usage Cycle	6	a		
	CO_2 Storage in Savanna Gras over 20 years	1,23	tCO_2/ha/a		Unique indicates 1,1 $tCO_2/ha_{bt}/a$

GHG potentials to be explored

1. Bush biomass regrowth in 20 years time frame tendentially to exceed 15tCO_{2eq}/ha instead of assumed 10.4tCO_{2eq}/ha in present scenario. *(e.g. Joubert (2008), Cunningham (2018))*

2. Transport emissions to Hamburg could be substantially lower both due to:

   a) New shipping technology that use sailing technology (currently developed in Hamburg port), almost offering CO_2 neutral cargo. *(Trilateral talks to Hamburg Port Authority)*

   b) Load capacity increase per each cargo in truck and rail. TransNamib indicated to increase wagon capacity. *(Personal talks to TransNamib and local forwarders)*

3. Increase of renewable energy share in the Biomass Park towards 100% electrification of processes using battery systems for night operations. (PV-battery LCOE in large-scale operations dropped down to 0.15 USD/kWh, which is already lower than power from the Namibian grid.)

4. If livestock emissions are accounted, CO_2 displacement effects for the use substitutes must be credited too, e.g.:

   a) rain-fed VS feed-lot beef, that substitutes GHG intense fattening in stables. *(https://www.agrarheute.com/tier/rind/us-studie-extensive-weidehaltung-schuetzt-klima-476109)*

   b) grass products and bush-feed as fodder alternatives, avoiding rain-forest damaging soya or maize import. *(https://trendeconomy.com/data/h2/Namibia/23)*

Conclusions

1) The overall GHG balance of the present model results in **negative emissions** (-9% ha base; 111% in contrast to natural gas emission) with values assumed conservative/cautious. This is mainly due to increased carbon storage in SOC and savanna grass.
2) In contrast to opponents that emphasize single and unilateral literature indications, there is a literary verifiable tendency discernible, that C_4 grasses in the present biome show higher carbon sequestration potential than C_3 bush. However, science does not provide a clear answer yet.
3) If the envisaged multifunctional-land-use system is truly practicable and applicable to Namibia and its biome can only be answered by **real practice**. A partnership could trigger the **scientific necessity** towards evidence. Measuring, repetition, method, dispute, etc. on scientific and practitioners level is needed.
4) With 1, 2 or 3 Biomass Industry Parks combined with a strong **code of conduct** in the partnership, proof of concept or falsification in different areas (rainfall patterns, species, soil types) could be effected. If the result speaks against export or even local use the damage potential is limited as long as rate of spread exceeds harvesting rate.

Questions?

Thank you for your attention!

Dr. Felix Flesch

Institute for applied Material Flow Management
Trier University of Applied Science
P.O. Box 1380
55761 Birkenfeld, Germany

Telephone	+49 6782 17 26 31
Fax	+49 6782 17 12 64
Email	f.flesch@umwelt-campus.de
Internet	www.stoffstrom.org

IfaS Institut für angewandtes Stoffstrommanagement

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