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SWOT and PEST analyses for implementation of reuse practices in Braunschweig, Germany

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Socio-economic characterization of the region

Braunschweig is a city in Lower Saxony, Germany. Nowadays, Braunschweig is the second-largest city in Lower Saxony and a major centre of scientific research and development. It has an area of 192 km² and 248,023 inhabitants. The agricultural and food industry has always occupied a central role in Lower Saxony: it is, after the car industry, the state's second-largest business sector. Although Germany is considered to be a water rich country with available water resources of 188 billion m³, in the region of Braunschweig, the overall balance over the last 50 years has been negative, which led to a stagnating recharge of groundwater. Most of the agricultural area in the region is characterized by sandy soils with low water-holding capacity which makes an intensive irrigation necessary. Taking that in account and in order to prevent falling groundwater levels the reuse of reclaimed water in agriculture is essential in this area. For irrigation of its fields AV-BS uses a mix of reclaimed water (90%) from the WWTP and groundwater (10%) which is abstracted on-site.

SWOT Analysis

Strength

General aspects	Specific aspects	AV-BS Braunschweig, Germany
Market related	Economic aspects	S11. Self-financing business model of AV-BS due to wastewater fees paid by customers
		S12. Lower costs due to selling biogas/electricity from biogas plant fed with irrigated energy crops
		S13. Regular financial support to AV-BS by German government for implementation of state-of-the-art technology
	Water availability	S14. Ideal geographical conditions of AV-BS region for agricultural irrigation: flat area and sandy soil
		S15. Need of irrigation due to negative climate balance during summer months in AV-BS region
	Markets	S16. Constant demand of reclaimed water by farmers due to negative climate balance and restricted groundwater extraction
		S17. Certain autonomy regarding food industry due to cultivation of energy crops
Product related	Technical aspects	S21. Successful long experience (60 years) of AV-BS with reclaimed water in agriculture
		S22. Successful technological solutions in reclaimed water for agriculture: pipeline system and irrigation machinery
	Technology transfer	S23. Due to successful long experience constant guidance of similar projects worldwide
		S24. Successful collaboration with national research institutes
	Health	S25. Constant medical checks and vaccination uptake of staff
		S26. Lines of hedges as limit for spray water from irrigation
		S27. Irrigated food products free of pollutants
Social & Governance	Social aspects	S31. Frequent possibilities for residents to visit and to get to know AV-BS and its system of reclaimed water (Open days, public meetings)
		S32. High degree of acceptance by residents due to long successful history of AV-BS

		S33. Frequent informative meeting for local farmers about news and trends
	Regulators	S34. Constant analysis of soil and groundwater parameters regarding pollutants S35. Frequent participation in legislation commissions
	Management	S36. Control of all AV-BS activities by supervisory board consisting of municipality representatives S37. Strong collaboration local farmers due to successful long experience S38. Well-established administrative system with clear responsibilities
	Environment	S39. Creation of a unique biosphere reserve for birds in form of water reservoir due to non-irrigation during winter

Weakness

General aspects	Specific aspects	AV-BS Braunschweig, Germany
Market related	Economic aspects	W11. High costs due to thermic disposal of sewage sludge
	Water availability	W12. General water abundance in Germany. Need for extra supply is not considered as a major issue
	Markets	W13. Market for sewage sludge disposal is problematic due to small capacities for thermic disposal W14. Mineral fertiliser less expensive compared to secondary fertilisers from sewage sludge
Product related Social & Governance	Technical aspects	W21. High maintenance effort for machinery of AV-BS
	Technology transfer	W22. Little capacity for technology transfer due to strong involvement in day-to-day business
	Health	W23. Certain health risk for staff and resident due to non-disinfection of reclaimed water
	Social aspects	W31. Concerns of resident and customers regarding health risks due to non-disinfection of reclaimed water and high heavy metal concentrations in soil due to former sewage sludge application

	Regulators	W32. Limitation of irrigation and application of organic fertilisers from biogas plant due to national fertilisation regulation (prevention of high nitrate concentrations in groundwater)
	Management	W33. Operator of WWTP in Braunschweig is private company, AV-BS as owner of WWTP is public entity, which leads to contrary business models (profit-oriented vs. Non-profit)
	Environment	W34. Detection of high concentration of micropollutants (pharmaceutical residues, contrast media) in groundwater under irrigated AV-BS fields

Opportunities

General aspects	Specific aspects	AV-BS Braunschweig, Germany
Market related	Economic aspects	O11. Enhancing field fertility by reclaimed water which leads to less application of mineral fertiliser
		O12. Increase of quality standards for municipal wastewater discharge makes irrigation of reclaimed water more attractive
	Water availability	O13. Increase of droughts caused by climate change combined with negative climate balance during summer make alternative irrigation method necessary in order to save groundwater resources
	Markets	O14. Expansion of Braunschweig model to regions of Germany with similar conditions due to negative climate balance and limited groundwater resources
O15. German promotion of renewable energies supports the Braunschweig Model with its biogas generation from energy crops		
Product related	Technical aspects	O21. Technology for 4th wastewater treatment (ozone, active carbon) becomes state-of-the-art which leads to increasing quality of reclaimed water

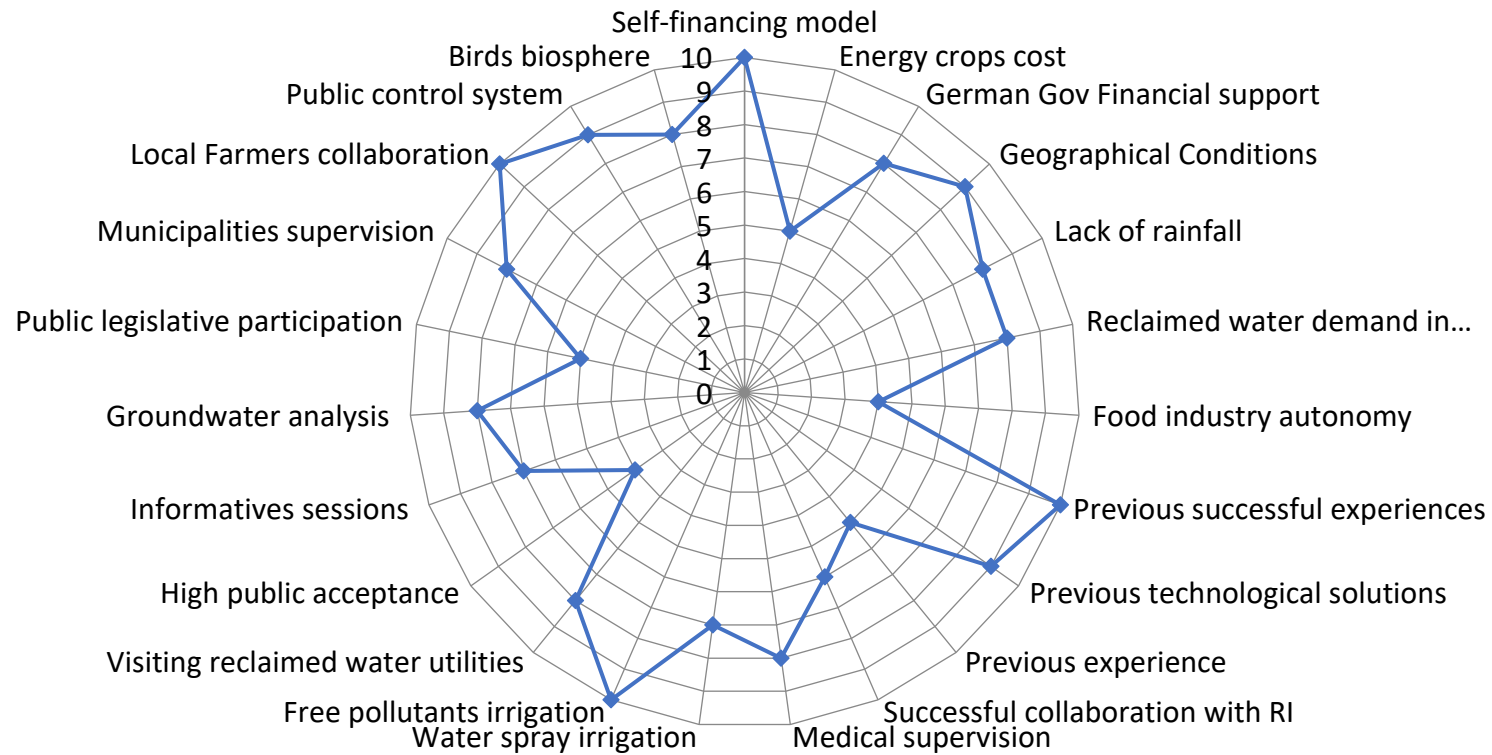
		O22. Technology for demand-based irrigation and fertilisation becomes state-of-the-art which leads to decreasing costs for farmers
	Technology transfer	O23. Worldwide increase of droughts and water shortage makes Braunschweig Model interesting in agricultural and wastewater sector
		O24. Constant promotion of technology and knowhow transfer by national and European funding's regarding requirements for climate change adaptation
	Health	O25. Technology for 4th wastewater treatment (incl. disinfection) becomes state-of-the-art which leads to pathogen free reclaimed water
Social & Governance	Social aspects	O31. Technology for 4th wastewater treatment (incl. disinfection) becomes state-of-the-art which leads to increasing acceptance by local community
		O32. Communities of parties and participatory workshops with relevant stakeholder lead to reduction of concerns
	Regulators	O33. Promotion of water reclamation by EU directive 91/271 which stipulates that „if possible, treated water should be re-used.“
		O34. Promotion of water reclamation by EU proposal COM(2018)337final which stipulates requirements for water reclamation
	Management	O35. Design of multi-barrier system with respect to increasing quality standards of reclaimed water and environmental regulations
	Environment	O36. Technology for 4th wastewater treatment (incl. Active carbon) becomes state-of-the-art which leads to reduction of micropollutants in reclaimed water
O37. Reduced application of mineral fertiliser (closed nutrient cycle) and groundwater extraction due to water reclamation is part of environment protection which is a major issue in Germany		

Threat

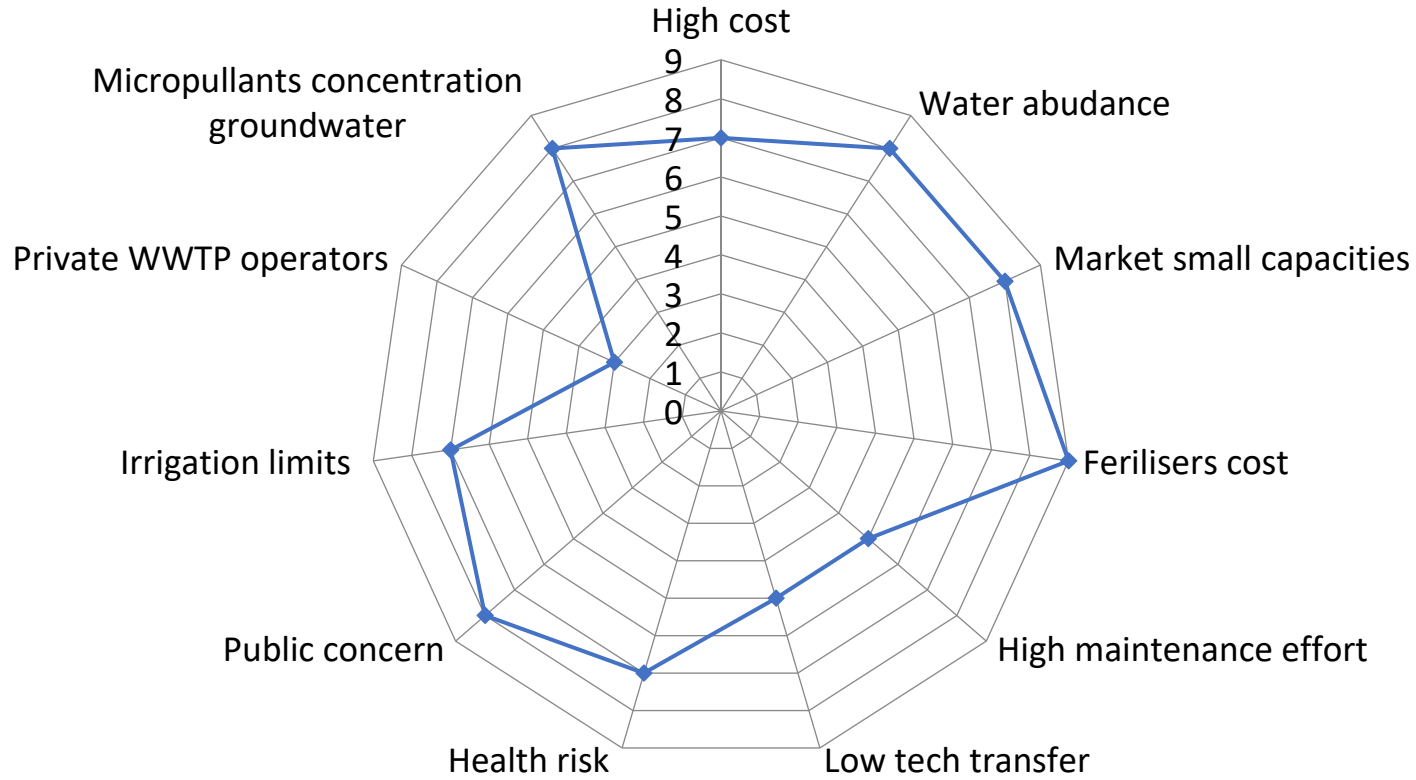
General aspects	Specific aspects	AV-BS Braunschweig, Germany
Market related	Economic aspects	T11. Price trends of mineral fertiliser are disadvantageous for sale of secondary fertilisers
		T12. Technology for 4th wastewater treatment is hardly affordable
		T13. Increasing costs for irrigation due to determination of the appropriate annual wastewater loading rates, the frequency, duration and application method
	Water availability	
	Markets	T14. No demand for secondary fertilisers due to minor quality compared to mineral fertilisers
Product related	Technical aspects	T21. Not many SMEs are acquainted with new technology levels
		T22. New technologies are scarcely implemented and mostly held on scientific scale then put in practice
	Technology transfer	T23. Conditions for water reclamation may vary from municipality to municipality which makes a one-to-one transfer of the Braunschweig Model difficult
	Health	T24. No implementation of technology for 4th wastewater treatment (incl. disinfection) which leads to health risks due to pathogens and micropollutants
Social & Governance	Social aspects	T31. Many farmers hold on to old habits and refuse to implement new technologies like secondary fertiliser or demand-based irrigation or fertilisation
		T32. Heavy concerns by consumers and residents regarding water reclamation due to risks to public health and to the environment
	Regulators	T33. Strict fertilisation regulations limit the application of reclaimed water
		T34. For German government there is no need of water reclamation which leads to heavy opposition against EU proposal of water reclamation regulation
	Management	T35. Closed nutrient and water cycles make a complex regional or national management necessary which includes all relevant stakeholders
Environment	T36. Reclaimed water does not always meet a quality standard that would enable its unrestricted discharge to the receiving environment which leads to environmental pollution	

To evaluate the different aspects, instead of sending a questionnaire to all relevant actors and stakeholder of the Braunschweig water reuse scheme in order to identify and evaluate SWOT aspects of Braunschweig, the stakeholders were brought together by AV-BS in form of a round table discussion. The AV-BS board of directors consisting of the management of AV-BS, authorities and political representatives, discussed together with farmers who are using the reclaimed water each SWOT category and identified the single aspects. All participants of the discussion had the possibility to contribute and share his opinion about the Braunschweig water reuse scheme regarding the SWOT categories. The identified SWOT aspects were evaluated and scored commonly with a single score number for each aspect as result.

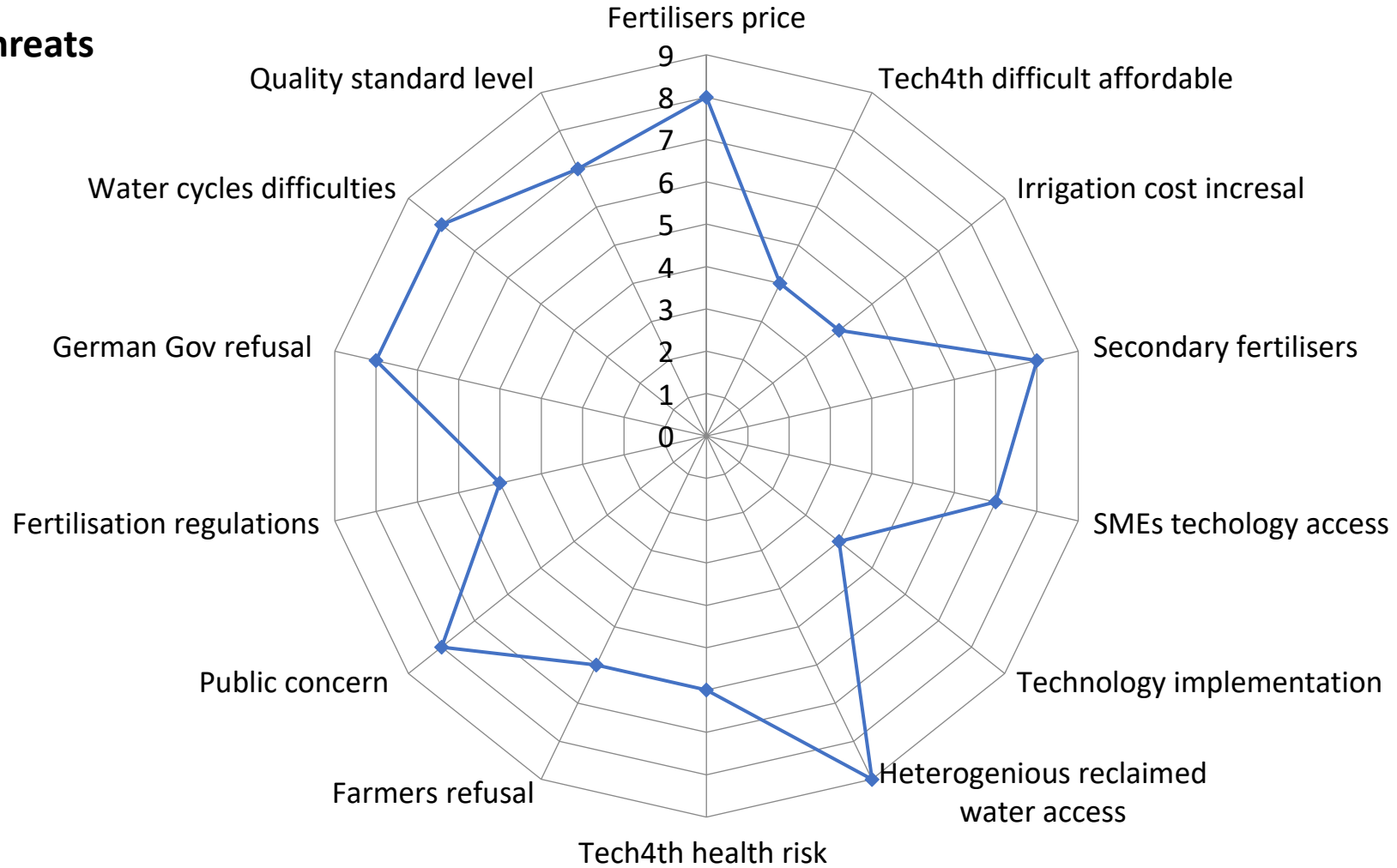
Strengths



Weaknesses



Threats



PEST Analysis combined with SWOT

PEST factors, referring to political (P), economic (E), social (S) and technological (T) determinants. PEST analysis complements the SWOT analysis by inserting each of the four components of SWOT analysis in the second dimension and generate a table with two classification factors. Some examples of this combined use are (Singh et al., 2018), (Ha and Coghill, 2008).

SWOT PEST	Strength (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
Political aspect (P)	<ul style="list-style-type: none"> • Frequent participation in legislation commissions • Control of all AV-BS activities by supervisory board consisting of municipality representatives 	<ul style="list-style-type: none"> • Limitation of irrigation and application of organic fertilisers from biogas plant due to national fertilisation regulation (prevention of high nitrate concentrations in groundwater) • Operator of WWTP in Braunschweig is private company, AV-BS as owner of WWTP is public entity, which leads to contrary business models 	<ul style="list-style-type: none"> • Promotion of water reclamation by EU directive 91/271 which stipulates that „if possible, treated water should be re-used.“ • Promotion of water reclamation by EU proposal COM(2018)337final which stipulates requirements for water reclamation 	<ul style="list-style-type: none"> • Strict fertilisation regulations limit the application of reclaimed water • For German government there is no need of water reclamation which leads to heavy opposition against EU proposal of water reclamation regulation

		(profit-oriented vs. Non-profit)		
Economic aspect (E)	<ul style="list-style-type: none"> • Self-financing business model of AV-BS due to wastewater fees paid by customers • Lower costs due to selling biogas/electricity from biogas plant fed with irrigated energy crops • Regular financial support to AV-BS by German government for implementation of state-of-the-art technology 	<ul style="list-style-type: none"> • High costs due to thermic disposal of sewage sludge 	<ul style="list-style-type: none"> • Enhancing field fertility by reclaimed water which leads to less application of mineral fertiliser • Increase of quality standards for municipal wastewater discharge makes irrigation of reclaimed water more attractive 	<ul style="list-style-type: none"> • Price trends of mineral fertiliser are disadvantageous for sale of secondary fertilisers • Technology for 4th wastewater treatment is hardly affordable • Increasing costs for irrigation due to determination of the appropriate annual wastewater loading rates, the frequency, duration and application method
Social aspect (S)	<ul style="list-style-type: none"> • Frequent possibilities for residents to visit and to get to know AV-BS and its system of reclaimed water (Open days, public meetings) 	<ul style="list-style-type: none"> • Concerns of resident and customers regarding health risks due to non-disinfection of reclaimed water and high heavy 	<ul style="list-style-type: none"> • Technology for 4th wastewater treatment (incl. disinfection) becomes state-of-the-art which leads to increasing acceptance by local community 	<ul style="list-style-type: none"> • Many farmers hold on to old habits and refuse to implement new technologies like secondary fertiliser or demand-based irrigation or fertilisation

	<ul style="list-style-type: none"> • High degree of acceptance by residents due to long successful history of AV-BS • Frequent informative meeting for local farmers about news and trends 	<p>metal concentrations in soil due to former sewage sludge application</p>	<ul style="list-style-type: none"> • Communities of parties and participatory workshops with relevant stakeholder lead to reduction of concerns 	<ul style="list-style-type: none"> • Heavy concerns by consumers and residents regarding water reclamation due to risks to public health and to the environment
<p>Technological aspect (T)</p>	<ul style="list-style-type: none"> • Successful long experience (60 years) of AV-BS with reclaimed water in agriculture • Successful technological solutions in reclaimed water for agriculture: pipeline system and irrigation machinery • Due to successful long experience constant guidance of similar projects worldwide 	<ul style="list-style-type: none"> • High maintenance effort for machinery of AV-BS • Little capacity for technology transfer due to strong involvement in day-to-day business 	<ul style="list-style-type: none"> • Technology for 4th wastewater treatment (ozone, active carbon) becomes state-of-the-art which leads to increasing quality of reclaimed water • Technology for demand-based irrigation and fertilisation becomes state-of-the-art which leads to decreasing costs for farmers 	<ul style="list-style-type: none"> • Not many SMEs are acquainted with new technology levels • New technologies are scarcely implemented and mostly held on scientific scale then put in practice • Conditions for water reclamation may vary from municipality to municipality which makes a one-to-one transfer of the Braunschweig Model difficult

Discussion and conclusion

The main findings of the SWOT analysis of AV-BS can be summarised as follows. Due to the long experience of AV-BS in the field of water reclamation the AV-BS model of reclamation stands for high financial autonomy and clear business structure. During the more than 60 years of activity of AV-BS a close partnership with the local farmers has been set up which leads to a high degree of acceptance among the local community. The successful long experience of the reclamation model of AV-BS is general based on favourable geological and climatic conditions in the region regarding field irrigation.

The missing 4th treatment stage during the reclamation process however is a problematic aspect of the AV-BS reclamation model which leads to rising micro pollutant concentration in groundwater and to concerns of the local habitants regarding the health risk of the reclaimed water due to the missing disinfection treatment. Besides field irrigation via reclaimed water is not considered as a major issue in the German public due to a general water abundance in Germany, which leads to less public promotion of water reclamation.

With respect to the future it can be stated that technologies for 4th wastewater treatment become more and more state-of-the-art and their implementation within the AV-BS model can lead to reduced concerns regarding health and environmental risks. Additionally, climate change challenges like increasing droughts and converting the energy sector to renewable energies will emphasize the advantages of the circular AV-BS reclamation model compared to end-of-pipe wastewater systems.

Despite climate change challenges there is no need of water reclamation for the German government which leads to heavy opposition against EU proposal of water reclamation as a regulation. Additional to the politic opposition closed nutrient and water cycles make a complex regional or national management necessary which includes all relevant stakeholders.