Climate Protection and Resource Conservation

Analysing the climate-resources nexus and interactions between international policy measures

Ecologic Institute Discussion Paper

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The responsibility for the content of this publication lies with the author(s).

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AP	Asia-Pacific
CDW	Construction and demolition waste
CO_2	Carbon dioxide
COP	Conference of the Parties
EOR+	CO_2-Enhanced Oil Recovery
EU ETS	European Emissions Trading Scheme
F-gases	Fluorinated greenhouse gases
FTIP	Federal Transport Infrastructure Plan
GHG	Greenhouse gas
H_2	Hydrogen
HGV	Heavy goods vehicle
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organisation
KSBV	UBA-study Klimaschutzbeitrag des Verkehrs bis 2050 [UBA, 2016a]
LAC	Latin America and the Caribbean
LEED	Leadership in Energy and Environmental Design
MENA	Middle East and North Africa
NDC	Nationally Determined Contributions (in Paris-Agreement)
NEDC	New European Driving Cycle
N_2O	Nitrous oxide
PJ	Petajoule (unit for energy)
PtG	Power-to-Gas (any electricity-based gaseous fuels)
PtL	Power-to-Liquid (any electricity-based liquid fuels)
RDE	Real Driving Emissions
RES	Renewable Energy Systems
TWh	Terawatt hours (unit for energy)
UNFCCC	United Nations Framework Convention on Climate Change
WLTP	Worldwide Harmonised Light-Duty Vehicles Test Procedure

Summary

Background

Climate protection is one of the most important, if not the most important, contemporary environmental policy issues, both on the national and the international level. While the 2015 "Paris Agreement" has marked a great success for climate protection in the international arena, there is a clear need to step up action in order to achieve the committed emission reductions. According to the International Resource Panel, natural resource extraction and processing account for more than 50% of total global GHG emissions. Thus, resource conservation and circular economy policy, e.g., increasing recycling or incentivising light weight construction methods, hold promising potential for reducing GHG emissions, and hence for climate protection.

While resource conservation is not as well established in international policy as climate protection, its importance as a relevant strategy for achieving climate goals is being increasingly recognized, for instance during G7 and G20 talks. Despite this encouraging development, interactions between climate and resource policy – the so-called "climate-resource-nexus" – still need to be much better understood and systemically analysed. So far, the climate-resource nexus has mostly been explored from a scientific perspective, which mainly centred on the Global North. Hence, further perspectives from the Global South are needed to better understand how these policy fields and their interrelations can be configured in different contexts.

Against this background, as part of the ICARE-project (Interactions between international measures for Climate Action and Resource Efficiency), the present study aimed to:

1. Investigate key findings on the climate-resource-nexus from literature
2. Identify international measures for climate protection and resource conservation and analyse these as regards
   i. possible interactions (synergies and trade-offs) between them,
   ii. their potential relevance and fit for different world regions

Key findings on the climate-resource-nexus from literature

The aim of the (1.) literature review on the climate-resource-nexus was to explore how potential interactions between climate protection and resource conservation are debated in contemporary scientific dialogues. Based on a multi-step selection process, we identified and reviewed more than 30 scientific publications regarding the climate-resource-nexus. This review revealed three main thematic clusters related to the nexus:

a) Investigation of the resource demand of climate-friendly technologies

b) Potential greenhouse gas savings through resource efficiency

c) The role of circular economy approaches for climate change mitigation

Cluster a) represented the largest fraction of publications identified for analysis of the climate-resources-nexus. This body of literature explores and discusses the resource demand for low-carbon technologies in order to substitute fossil fuels and to transform the energy sector, address a transition towards climate-friendly infrastructures and technologies on a large scale. The identified studies, mostly with focus on the energy and mobility sector, centred their analysis on the following question: *Is it feasible to implement an ambitious climate policy with modern, metal-intense technologies, or do resource constraints hinder these endeavours?* Answers to this question varied across the literature: from considering the transition to low-carbon technologies as challenge for the overall supply of (critical) metals, to concluding that the reserves are sufficient

for this transitions, assuming a dynamic development of material intensity over time. In most cases, measures such as recycling, reducing material intensity and the substitution of critical raw materials were recommended.

Cluster b) studies explore in what ways resource efficiency or material efficiency approaches contribute to reducing greenhouse gas emissions, focusing more on industrial resource conservation through efficiency increases and not so much on waste management and closing loops (cluster c)). A number of studies start from an apparent knowledge gap regarding the relationship between resource conservation strategies and climate mitigation, which suggests an untapped potential to reduce greenhouse gas emissions by increasing resource efficiency. All studies in this cluster conclude that there is indeed a big potential for resource efficiency strategies to contribute positively to climate change mitigation. Studies differ mainly in the expected magnitude of this potential, the identified challenges to achieve it, and the proposed policy measures to address them.

Cluster c) publications focus on circular economy strategies, i.e. keeping raw materials and their economic value as long as possible in the loop, addressing the entire life cycle from design to waste management. The basic assumption of the studies is that circular economy strategies do not only conserve resources but also have the potential to reduce greenhouse gas emissions. The majority of studies in this cluster focus on specific economic sectors (e.g. the building sector), materials (e.g. metals) or strategies (e.g. re-use), and their respective contributions to climate change mitigation. A number of studies take a broader look at making the economy as a whole more circular.

Analysis of international measures for climate protection and resource conservation

For this analysis, we used experience from past and ongoing projects as well as literature review to identify relevant policy measures, both of climate protection and resource conservation. We understand "measures" as more overarching areas for policy intervention to pursue certain policy objectives, for which different policy instruments (i.e. concrete implementation approaches, for instance a tax for CO_2 or single-use plastics) are needed. After a process of selection and detailed description of the measures we arrived at *six* measures for climate protection and *eight* measures for resource conservation.

Depending on the regional particularities like governance structures or culture, the focus and prioritisation of the measures can vary, as well as the set of instruments potentially serving for implementing the measures. Therefore, in order to assess the regional relevance, fit and specificities of the measures, we conducted semi-structured interviews with regional experts mainly from UN institutions, but also from environmental NGOs and academia. Our target group were experts working formally in the different world regions (Africa; Asia-Pacific, AP; Latin America and the Caribbean, LAC; Middle East and North Africa, MENA; North America, NA) and have expertise either on resource conservation or climate protection. We conducted eight interviews for climate protection and five for resource conservation. In certain cases, due to difficulties to find candidates with an entirely regional expertise, we interviewed experts from relevant countries of different world regions. These countries were: China, Mexico, Saudi Arabia, South Africa and the USA.

Findings for measures of climate protection:

1) Shifting to 100% Renewable Energy:

   The shift to a 100% renewable energy is a key measure as it has the potential to significantly reduce GHG emissions; however, full implementation is currently regarded as unrealistic due to economic and cultural restraints.

2) Increasing Electrification:

   Electrification is a relevant measure, which is closely intertwined with 100% renewable energy. However, increased electrification would put additional pressure on the electrical grid, which in many regions is often already at its maximum capacity.

3) Shifting to Zero-Emission Buildings:

   Shifting to Zero-Emission Buildings is a relevant measure (for both old and new buildings), in which energy efficiency standards can play an important role. However, challenges arise from the situation that the shift is in most parts of the world not economically viable due to low energy costs and from split incentives.

4) Reducing Fertilizer Use and Liquid Manure Input on Fields

   The reduction of fertilizers and of liquid manure input on fields was not supported by the expertise of most the interviewees since the topic was not within their field of work. However, it was closely linked by interviewees to carbon sinks as well as adding land-use in general and was therefore addressed together with measure 6

5) Changing Life-Styles and Sufficiency

   Changing life-styles and increasing sufficiency was considered a relevant measure, but very difficult to implement as changing habits and consumptions patterns poses a formidable challenge. In some regions safe spaces for recreation are limited to places for consumption. In South Africa and Southern Africa, improving the urban infrastructure has the potential to reduce GHG emissions. Currently, there is a high dependency on cars. Public transport is not safe to use, as well as polluting due to the use of old buses imported from Europe. The lack of safety of public spaces was also mentioned in Mexico as a barrier to changing lifestyles.

6) Increasing Natural Carbon Sinks

   Improving agricultural practices and increasing carbon sinks is not regarded as a key measure. This, however, might reflect the topical focus of the interviewees on other fields of actions. A key challenge for this measure is the line-up against or joining with economic activities.

In four out of the five regions covered in interviews the measure '*shifting to 100% renewable energy*' emerged as a top measure. Only in the MENA region other measures were considered more urgent or relevant, in particular decarbonising fossils fuels and the measure '*increasing natural carbon sinks*'. The measure '*increasing electrification*' featured as a relevant measure in Africa, AP, LAC and the USA, while the measure '*increasing natural carbon sinks*' is considered relevant in AP, LAC and MENA. Interestingly, the measure '*changing lifestyles and sufficiency*' ranked among most relevant measures in Africa, AP and LAC, but was not listed for MENA nor the USA. The measure '*shifting to zero-emission buildings*' was identified as a relevant measure in AP and the USA. No interviewee considered the measure '*reducing fertilizer use and liquid manure input on fields*' among those most relevant.

Findings for measures of resource conservation

1) Setting a global per-capita resource use budgets

   Setting global per capita budgets for resource use is considered unthinkable in the current political economy of the regions interviewed, but developed countries taking the lead by example and providing concessions to developing countries could help.

2) Raising prices of virgin materials

   Taxing raw material use is considered to conflict with regional economies depending on the raw materials sector. Complex global value chains and a generic lack of acceptance of taxing further complicate this measure.

3) Fostering markets for sustainable products and secondary raw materials

   Fostering secondary raw material markets appears as the most relevant of all measures and is seen as a clear win-win approach use. Increasing the demand for secondary materials is key, but lacking capacities and technologies for proper waste management are challenging this.

4) Designing products and business models for material efficiency and long service life

   Designing products and business models for material efficiency and a circular economy is seen as having great potential, but rather in the longer run. Relevant challenges encompass modern consumerist cultures as well as lower prices for virgin than secondary materials and products.

5) Making re-use and repair of products easier and more attractive

   Re-use and repair are relevant in low to middle-income countries, in which repair is also more deeply enshrined in culture. This measure has promising potential for job creation, but product and business model design often counteract re-use and repair.

6) Reducing plastic waste

   Reducing plastic waste is considered relevant in all regions, but existing collection and sorting systems pose a key challenge and lead to plastic waste being littered.

7) Making the built environment more material efficient

   Making the built environment more sustainable is a relevant, yet challenging issue particularly in highly urbanised regions, experiencing or expecting population growth. Legislation and technology are often not efficient enough to build more circular.

8) Creating a sustainable food system

   Reducing food waste is a central focus of making food systems more sustainable in most regions. Cultural aspects make the uptake of plant-based diets difficult.

Across all eight resource conservation measures, the measure '*fostering markets for sustainable products and secondary raw materials*' ranked among the most relevant measures in four out of the five regions covered: Africa, AP, LAC and the USA. The measure '*reducing plastic waste*' featured among the most relevant measures in Africa, MENA and the USA. The following resource conservation measures each emerged among the most relevant measures in two of the five regions covered: '*Making re-use and repair of products easier and more attractive'*, for Africa and MENA; '*Making the built environment more material efficient*', for AP and LAC; '*Designing for material efficiency and long service life'*, for AP and LAC; and '*Creating a sustainable food system'*, for

MENA and the USA. The measure '*raising prices of virgin materials*' only featured among the most relevant measures in LAC. No interviewee considered the measure '*setting a global per-capita resource use budgets*' among those most relevant.

With respect to the interactions between climate protection and resources conservation measures overall, very few interviewees indicated interactions between climate protection and resource conservation measures. On general terms, climate protection interviewees mainly stated that a more efficient use and the recycling of resources also reduces GHG emissions compared to extraction, production, processing and transport of virgin materials and products. Similarly, resource conservation interviewees generally recognised that all measures could have an important impact on reducing GHG emissions. However, a variety of trade-offs between climate mitigation and resource conservation were identified by experts of different regions. These had to do on the one hand with the increase in demand of (critical) materials caused by the shift to renewable energy (which aligns with the findings of publications of cluster a in the literature review). On the other hand, resource conservation experts for regions such as Africa and AP also pointed out the trade-off for development which resource conservation measures can have in countries that are economically dependent on the extractive industries and are themselves low GHG emitters. The complexity of this global perspective was also highlighted by the interviewee for the USA, who argued that climate protection co-benefits from resource conservation needs to be made more explicit especially companies in the global north. Only through that it will be possible to make a value-add proposition from resource conservation and scale it up to the level required for achieving significant emissions reductions.

Conclusion

This study portrays a mosaic of different climate and resource policy pathways, starting from differing levels of policy ambition and socio-political feasibility. Different policy pathways start from a need for more awareness raising and education for the population in most regions (developing and developed alike) to creating the right and enabling infrastructures (from a stable grid to waste management infrastructure to safe outdoor leisure activities and public transport).

Renewable energy potential in all regions is large, but they face various challenges to compete with fossil fuels. Furthermore, in many regions the electrical grid is weak and electricity outages are frequent. Therefore, where a shift to 100% renewable energy might not be feasible or only in the long-term, other technologies for decarbonising fuel use (e.g. carbon capture technologies) might constitute an important milestone on the path towards 100% renewable energy.

Buildings are in focus of climate protection in regions with either high urbanisation rates, as in AP, or where building standards for energy (and material) efficiency are low or lacking. In this context, using renewable energy to service heating and cooling needs seems key. On the other hand, buildings are not considered a key focus with respect to resource conservation in many regions, apart from water and energy protection, even though the use of recyclates from CDW were considered relevant by some interviewees. However, where large floor space or building area per person is an issue, as in the USA, lifestyle changes and sufficiency also become an issue in the building sector

Moreover, lifestyle changes and sufficiency appear very promising, yet very difficult to impossible to implement in the current political economy and social debates. Culture and tradition counter-act such changes, particularly regarding meat consumption as a(n emerging) status symbol on culturally deeply rooted. However, diets prove a main focus of both climate protection and resource conservation and both the younger and in urban population show trends towards more

sustainable lifestyles, e.g. vegetarian and vegan diets. While this is this is far from mainstream in any region, interviewees suggested to go through popular or religious figures to make such changes something aspirational and credible. A similar approach could be tried where tradition promotes food waste generation due to a culture of preparing and serving more food than could possibly be eaten.

While the climate-resource-nexus did not feature prominently in the interviews, its main aspects identified in the literature review were also addressed by the interviewed experts, namely that:

- A full lifecycle perspective is needed to assess whether shifting to renewable energy and increasing electrification will be overall environmental and climate benefits or not with respect to its (critical) raw material and infrastructure demand
- Reducing the need for virgin materials and increasing the use of secondary materials across industry sectors and consumers –like lifestyle changes towards more re-use, re-pair and plant-based diets– also reduces energy needs and GHG emissions.

Zusammenfassung

Hintergrund

Klimaschutz ist eines der wichtigsten, wenn nicht sogar das wichtigste umweltpolitische Thema der Gegenwart, sowohl auf nationaler als auch auf internationaler Ebene. Das "Pariser Abkommen" von 2015 ist zwar ein großer Erfolg für den Klimaschutz auf internationaler Ebene, doch es besteht ein klarer Handlungsbedarf, um die zugesagten Emissionsreduktionen zu erreichen. Nach Angaben des International Resource Panel sind die Gewinnung und Verarbeitung natürlicher Ressourcen für mehr als 50% der gesamten globalen Treibhausgas (THG)-Emissionen verantwortlich. Ressourcenschonung und Kreislaufwirtschaft bergen z.B. durch vermehrtes Recycling oder Anreize für Leichtbauweisen vielversprechende Potenziale für die Reduktion von THG-Emissionen und damit für den Klimaschutz.

Zwar ist Ressourcenschonung in der internationalen Politik nicht so verankert wie der Klimaschutz, aber ihre Bedeutung als relevante Strategie zur Erreichung der Klimaziele wird zunehmend anerkannt, z.B. bei den G7- und G20-Gesprächen. Trotz dieser ermutigenden Entwicklung müssen die Wechselwirkungen zwischen Klima- und Ressourcenpolitik – der so genannte "Klima-Ressourcen-Nexus" – noch viel besser verstanden und systemisch analysiert werden. Bislang wurde der Klima-Ressourcen-Nexus vor allem aus einer wissenschaftlichen Perspektive untersucht, die sich vor allem auf den globalen Norden konzentrierte. Daher sind weitere Perspektiven aus dem globalen Süden erforderlich, um besser zu verstehen, wie diese Politikfelder und ihre Wechselbeziehungen in verschiedenen Kontexten gestaltet werden können.

Vor diesem Hintergrund wurden im Rahmen des ICARE-Projekts („Interactions between international measures for Climate Action and Resource Efficiency“) die folgenden Aktivitäten durchgeführt:

1. Untersuchung wesentlicher Erkenntnisse zum Klima-Ressourcen-Nexus aus der Literatur
2. Identifikation und Analyse internationaler Maßnahmen zum Klima- und Ressourcenschutz hinsichtlich
   i. möglicher Interaktionen (Synergien und negative Wechselwirkungen),
   ii. ihrer potentiellen Relevanz und Eignung für verschiedene Weltregionen

Wesentliche Erkenntnisse zum Klima-Ressourcen-Nexus aus der Literatur

Ziel der (1.) Literaturrecherche zum Klima-Ressourcen-Nexus war es, zu untersuchen, wie mögliche Wechselwirkungen zwischen Klima- und Ressourcenschutz im aktuellen wissenschaftlichen Diskurs dargestellt werden. Auf der Grundlage eines mehrstufigen Auswahlverfahrens wurden mehr als 30 wissenschaftliche Publikationen zum Klima-Ressourcen-Nexus identifiziert und gesichtet. Diese Überprüfung ergab drei thematische Hauptcluster, die mit dem Nexus in Verbindung stehen:

a) Untersuchung des Ressourcenbedarfs klimafreundlicher Technologien

b) mögliche THG-Emissionseinsparungen durch Ressourceneffizienz

c) die Rolle der Kreislaufwirtschaftsansätze für die Minderung des Klimawandels

Der Cluster a) stellte den größten Anteil der für die Analyse des Klima-Ressourcen-Nexus identifizierten Publikationen dar. In dieser Literatur wird der Ressourcenbedarf für kohlenstoffarme Technologien zur Substitution fossiler Brennstoffe und zur Transformation des Energiesektors sowie der Übergang zu klimafreundlichen Infrastrukturen und Technologien in großem Maßstab untersucht und diskutiert. Die identifizierten Studien, meist mit Schwerpunkt auf dem Energie-

und Mobilitätssektor, konzentrierten ihre Analysen auf die folgende Frage: Behindern Ressourcenbeschränkungen bzw. -verfügbarkeiten eine ehrgeizige Klimapolitik mit modernen, kohlenstoffarmen Technologien? Die Antworten auf diese Frage variierten in der Literatur: von der Betrachtung des Übergangs zu kohlenstoffarmen Technologien als Herausforderung für die Gesamtversorgung mit (kritischen) Metallen bis zur Schlussfolgerung, dass die Reserven für diesen Übergang ausreichen, wobei eine dynamische Entwicklung der Materialintensität im Laufe der Zeit angenommen wird. In den meisten Fällen wurden Maßnahmen wie Recycling, Verringerung der Materialintensität und die Substitution kritischer Rohstoffe empfohlen.

Cluster b) Studien untersuchen, auf welche Weise Ansätze zur Steigerung von Ressourcen- oder Materialeffizienz zur Verringerung der THG-Emissionen beitragen, wobei der Schwerpunkt eher auf der industriellen Ressourcenschonung durch Effizienzsteigerungen und weniger auf der Abfallwirtschaft und der Schließung von Kreisläufen liegt (siehe Cluster c)). Eine Reihe von Studien geht von einer bestehenden Wissenslücke hinsichtlich der Beziehung zwischen Ressourcen- und Klimaschutz aus, die auf ein ungenutztes Potenzial zur Verringerung der THG-Emissionen durch Steigerung der Ressourceneffizienz hinweist. Alle Studien in diesem Cluster kommen zu dem Schluss, dass es in der Tat ein großes Potential für Strategien zur Steigerung der Ressourceneffizienz gibt, um einen positiven Beitrag zur Minderung des Klimawandels zu leisten. Die Studien unterscheiden sich vor allem in der erwarteten Größe dieses Potentials, den identifizierten Herausforderungen zur Erreichung dieses Potentials und den vorgeschlagenen politischen Maßnahmen zu deren Bewältigung.

Cluster c) Veröffentlichungen konzentrieren sich auf Strategien der Kreislaufwirtschaft, d.h. Rohstoffe und ihren wirtschaftlichen Wert so lange wie möglich im Kreislauf zu halten, wobei der gesamte Lebenszyklus vom Design bis zur Abfallentsorgung berücksichtigt wird. Die Grundannahme der Studien ist, dass Kreislaufwirtschaftsstrategien nicht nur Ressourcen schonen, sondern auch das Potential haben, THG-Emissionen zu reduzieren. Die meisten Studien in diesem Cluster konzentrieren sich auf bestimmte Wirtschaftssektoren (z.B. den Bausektor), Materialien (z.B. Metalle) oder Strategien (z.B. Wiederverwendung) und ihre jeweiligen Beiträge zur Minderung des Klimawandels. Eine Reihe von Studien befasst sich mit einer breiteren Sichtweise, um die Wirtschaft als Ganzes zirkulärer zu gestalten.

Analyse der internationalen Maßnahmen zum Klima- und Ressourcenschutz

Für diese Analyse haben wir Erfahrungen aus vergangenen und laufenden Projekten sowie eine Literaturrecherche genutzt, um relevante politische Maßnahmen sowohl im Bereich des Klimaschutzes als auch der Ressourcenschonung, zu identifizieren. Unter "Maßnahmen" verstehen wir eher übergreifende politische Interventionsansätze, die bestimmte politische Ziele verfolgen, für die wiederum unterschiedliche politische Instrumente (d.h. konkrete Umsetzungsansätze, z.B. eine Steuer für CO2 oder Einwegkunststoffe) benötigt werden. Insgesamt wurden sechs Maßnahmen zum Klimaschutz und acht Maßnahmen zur Ressourcenschonung identifiziert und beschrieben.

Je nach regionalen Besonderheiten, wie z.B. Governance-Strukturen oder kulturelle Prägungen, können die Schwerpunkte und die Priorisierung der Maßnahmen sowie das Instrumentarium, das zur Umsetzung der Maßnahmen dienen kann, variieren. Um die regionale Relevanz und Passung der Maßnahmen zu beurteilen, haben wir halbstrukturierte Interviews mit regionalen Expert*innen vor allem aus UN-Institutionen, aber auch aus Umweltverbänden und der Wissenschaft durchgeführt. Unsere Zielgruppe waren Expert*innen, die formell in den verschiedenen Weltregionen (Afrika; Asien-Pazifik, AP; Lateinamerika und Karibik, LAK; Naher Osten und Nordafrika, MENA; Nordamerika, NA) tätig sind und sich entweder mit Ressourcenschutz oder

Klimaschutz beschäftigen. Wir haben acht Interviews für den Klimaschutz und fünf für den Ressourcenschutz durchgeführt. In bestimmten Fällen haben wir aufgrund der Schwierigkeiten, Kandidat*innen mit ausschließlich regionaler Expertise zu finden, Expert*innen aus relevanten Ländern verschiedener Weltregionen befragt. Diese Länder waren: China, Mexiko, Saudi-Arabien, Südafrika und die USA.

Erkenntnisse für Maßnahmen des Klimaschutzes:

1) Umstellung auf 100% erneuerbare Energien:

   Die Umstellung auf 100% erneuerbare Energien ist eine Schlüsselmaßnahme, da sie das Potential hat, die THG-Emissionen deutlich zu reduzieren; die vollständige Umsetzung wird jedoch aufgrund wirtschaftlicher und kultureller Zwänge derzeit als nicht realistisch angesehen.

2) Ausbau der Elektrifizierung:

   Die Elektrifizierung ist eine relevante Maßnahme, die eng mit 100% erneuerbarer Energie verbunden ist. Eine verstärkte Elektrifizierung würde jedoch zusätzlichen Druck auf das Stromnetz ausüben, das in vielen Regionen bereits an der Grenze seiner Leistungsfähigkeit angelangt ist.

3) Umstieg zu Null-Emissions-Gebäuden:

   Der Umstieg auf Null-Emissions-Gebäude ist eine relevante Maßnahme (sowohl für alte als auch für neue Gebäude), bei der Energieeffizienzstandards eine wichtige Rolle spielen können. Herausforderungen ergeben sich insbesondere daraus, dass niedrige Energiekosten und geteilten Anreize in den meisten Teilen der Welt den Umstieg auf Null-Emissions-Gebäude nicht wirtschaftlich machen.

4) Reduzierung des Düngemitteleinsatzes und des Gülleeinsatzes auf den Feldern

   Die Reduzierung von Düngemitteln und des Gülleeintrags auf die Felder wurde von den meisten Befragten nicht unterstützt, da das Thema nicht in ihren Arbeitsbereich fiel. Sie war jedoch von den Befragten eng mit Kohlenstoffsenken sowie mit der Einbeziehung der Landnutzung im Allgemeinen verknüpft und wurde daher zusammen mit Maßnahme 6 behandelt.

5) Veränderung von Lebensstilen und Erhöhung der Suffizienz

   Die Änderung des Lebensstils und die Erhöhung der Suffizienz wurde als eine relevante Maßnahme angesehen, die jedoch sehr schwierig umzusetzen ist, da die Änderung von Gewohnheiten und Konsummustern eine große Herausforderung darstellt. In einigen Regionen sind sichere Räume für die Erholung auf Orte des Konsums beschränkt. In Südafrika hat die Verbesserung der städtischen Infrastruktur das Potential, die THG-Emissionen zu reduzieren. Gegenwärtig besteht eine hohe Abhängigkeit vom motorisierten Individualverkehr. Die öffentlichen Verkehrsmittel sind nicht sicher zu benutzen und verschmutzen die Umwelt durch den Einsatz alter Busse, die aus Europa importiert wurden. Die mangelnde Sicherheit des öffentlichen Raums wurde auch in Mexiko als ein Hindernis für einen veränderten Lebensstil genannt.

6) Erhöhung der natürlichen Kohlenstoffsenken

   Die Verbesserung der landwirtschaftlichen Praktiken und die Erhöhung der Kohlenstoffsenken werden nicht als Schlüsselmaßnahme angesehen. Dies könnte jedoch den aktuellen Fokus der Befragten auf andere Handlungsfelder widerspiegeln. Eine zentrale Herausforderung für diese Maßnahme ist die Wirtschaftlichkeit.

In vier der fünf interviewten Regionen wurde die Maßnahme "Umstellung auf 100% erneuerbare Energien" als wichtigste bzw. einer der wichtigsten Maßnahmen benannt. Nur in der MENA-Region wurden andere Maßnahmen als dringlicher oder relevanter angesehen, insbesondere die Dekarbonisierung fossiler Brennstoffe und die Maßnahme "Erhöhung der natürlichen Kohlenstoffsenken". Die Maßnahme "Ausbau der Elektrifizierung" wurde in Afrika, AP, LAK und den USA als relevante Maßnahme genannt, während die Maßnahme "Erhöhung der natürlichen Kohlenstoffsenken" in AP, LAK und MENA als relevant angesehen wird. Interessanterweise zählte die Maßnahme "Veränderung der Lebensweise und der Suffizienz" zu den wichtigsten Maßnahmen in Afrika, AP und Lateinamerika/Karibik, wurde aber weder für MENA noch für die USA aufgeführt. Die Maßnahme "Umstieg auf Null-Emissions-Gebäude" wurde in AP und den USA als eine relevante Maßnahme identifiziert. Keiner der Befragten betrachtete die Maßnahme "Reduzierung des Düngemitteleinsatzes und des Gülleeinsatzes auf den Feldern" als eine der relevantesten Maßnahmen.

Erkenntnisse für Maßnahmen zur Ressourcenschonung

1) Festlegung eines globalen Pro-Kopf-Budgets für die Ressourcennutzung

   Die Festlegung globaler Pro-Kopf-Budgets für die Ressourcennutzung wird in der gegenwärtigen politischen Ökonomie der befragten Regionen als undenkbar angesehen, aber es könnte helfen, wenn die Industrieländer mit gutem Beispiel vorangehen und den Entwicklungsländern Zugeständnisse machen.

2) Erhöhung der Preise für Primärrohstoffe

   Die Besteuerung der Rohstoffnutzung führt potentiell zu Konflikten in den regionalen Wirtschaften, die vom Rohstoffsektor abhängig sind. Komplexe globale Wertschöpfungsketten und eine allgemein mangelnde Akzeptanz der Besteuerung erschweren diese Maßnahme zusätzlich.

3) Förderung der Märkte für nachhaltige Produkte und Sekundärrohstoffe

   Die Förderung von Sekundärrohstoffmärkten erscheint als die relevanteste aller Maßnahmen und wird als klarer Win-Win-Ansatz gesehen. Die Steigerung der Nachfrage nach Sekundärrohstoffen ist der Schlüssel, aber fehlende Kapazitäten und Technologien für eine ordnungsgemäße Abfallentsorgung erschweren dies.

4) Design von Produkten und Geschäftsmodellen für Materialeffizienz und lange Lebensdauer

   Die Gestaltung von Produkten und Geschäftsmodellen für Materialeffizienz und Kreislaufwirtschaft wird als ein großes Potential angesehen, allerdings eher auf lange Sicht. Relevante Herausforderungen umfassen moderne Konsumkulturen sowie niedrigere Preise für Neuware als für Sekundärmaterialien und -produkte.

5) Die Wiederverwendung und Reparatur von Produkten einfacher und attraktiver machen

   Wiederverwendung und Reparatur sind in Ländern mit niedrigem bis mittlerem Einkommen relevant, in denen die Reparatur auch kulturell tiefer verankert ist. Diese Maßnahme hat ein vielversprechendes Potenzial für die Schaffung von Arbeitsplätzen, aber die Gestaltung von Produkten und Geschäftsmodellen wirkt Wiederverwendung und Reparatur oft entgegen.

6) Reduzierung von Kunststoffabfällen

   Die Reduzierung von Kunststoffabfällen wird in allen Regionen als relevant angesehen, aber die bestehenden Sammel- und Sortiersysteme stellen eine zentrale Herausforderung dar und führen auch zu mehr Vermüllung der Umwelt mit Kunststoffabfällen.

7) Die gebaute Umwelt materialeffizienter machen

   Eine nachhaltigere Gestaltung der bebauten Umwelt ist ein relevantes, aber dennoch herausforderndes Thema, insbesondere in stark verstädterten Regionen, die ein Bevölkerungswachstum erfahren oder erwarten. Gesetzgebung und Technologie sind oft nicht effizient genug, um eine zirkuläre Bauweise zu ermöglichen.

8) Schaffung eines nachhaltigen Ernährungssystems

   Die Verringerung der Lebensmittelabfälle ist ein zentraler Punkt, um die Lebensmittelsysteme in den meisten Regionen nachhaltiger zu gestalten. Kulturelle Aspekte erschweren einen größeren Anteil von pflanzlicher Ernährung.

Bei allen acht Maßnahmen zur Ressourcenschonung gehörte die Maßnahme "Förderung der Märkte für nachhaltige Produkte und Sekundärrohstoffe" in vier der fünf erfassten Regionen (Afrika, AP, LAC und USA) zu den wichtigsten Maßnahmen. Die Maßnahme "Reduzierung von Plastikabfällen" zählte zu den wichtigsten Maßnahmen in Afrika, MENA und den USA. Die folgenden Maßnahmen zur Ressourcenschonung gehörten in zwei der fünf erfassten Regionen zu den relevantesten Maßnahmen: "Erleichterung der Wiederverwendung und Reparatur von Produkten" für Afrika und MENA; "Materialeffizientere Gestaltung der bebauten Umwelt" für AP und Lateinamerika/Karibik; "Materialeffizienz und Langlebigkeit" für AP und Lateinamerika/Karibik; und "Schaffung eines nachhaltigen Ernährungssystems" für MENA und die USA. Die Maßnahme "Erhöhung der Preise für Primärrohstoffe" gehörte nur in LAK zu den wichtigsten Maßnahmen. Keiner der Befragten betrachtete die Maßnahme "Festlegung eines globalen Pro-Kopf-Budgets für die Ressourcennutzung" als eine der relevantesten Maßnahmen.

Hinsichtlich der Wechselwirkungen zwischen Klima- und Ressourcenschutzmaßnahmen insgesamt gaben die befragten Klimaschutzexpert*innen vor allem an, dass eine effizientere Nutzung und Verwertung von Ressourcen auch die THG-Emissionen im Vergleich zur Gewinnung, Produktion, Verarbeitung und zum Transport von Primärrohstoffen und neuen Produkten reduziert. Ebenso erkannten die Befragten im Bereich des Ressourcenschutzes allgemein an, dass alle Maßnahmen einen wichtigen Einfluss auf die Reduzierung der THG-Emissionen haben können. Allerdings wurden von Expert*innen verschiedener Regionen eine Reihe von negativen Wechselwirkungen zwischen Klimaschutz und Ressourcenschutz identifiziert - diese hatten beispielsweise mit der steigenden Nachfrage nach (kritischen) Materialien zu tun, die durch die Umstellung auf erneuerbare Energien verursacht wurde (was mit den Ergebnissen der Veröffentlichungen von Cluster a in der Literaturübersicht übereinstimmt). Andererseits wiesen Ressourcenschonungsexpert*innen in Regionen wie Afrika und AP auch auf mögliche Nachteile für die regionale Entwicklung hin, die Maßnahmen zum Ressourcenschutz in Ländern mit hoher Abhängigkeit von der Rohstoffindustrie und geringen THG-Emissionen haben können. Die Komplexität dieser globalen Perspektive wurde auch im Interview mit den USA deutlich, denn die Synergieeffekte, welche Ressourcenschonung auch für den Klimaschutz bietet, sollten Unternehmen und Akteuren im globalen Norden expliziter gemacht und deren Anwendung unterstützt werden. Nur so wird es möglich sein, Ressourcenschutz zu einem Mehrwert für Klimaschutz zu machen und dadurch gemeinsam Klima- und Ressourcenschutz auf das Niveau zu bringen, das für eine langfristige Einhaltung planetarer Grenzen erforderlich ist.

Fazit

Die Studie zeigt ein Mosaik verschiedener klima- und ressourcenpolitischer Wege, ausgehend von unterschiedlichen politischen Ambitionen und gesellschaftspolitischer Machbarkeit. Die verschiedenen politischen Wege reichen von der Notwendigkeit einer stärkeren Sensibilisierung und Bildung der Bevölkerung in den meisten Regionen (sowohl in Entwicklungs- als auch in Entwicklungsregionen) bis zur Schaffung entsprechender, Ressourcenschonung und Klimaschutz ermöglichenden Infrastrukturen (von einem stabilen Energienetz über Infrastrukturen der Abfallwirtschaft bis hin zu sicheren öffentlichen Verkehrsmitteln).

Das Potential an erneuerbaren Energien ist in allen Regionen groß, aber deren Nutzung steht vor verschiedenen Herausforderungen, um mit den fossilen Brennstoffen konkurrieren zu können. Darüber hinaus ist in vielen Regionen das Stromnetz schwach und Stromausfälle sind häufig. Daher könnten dort, wo eine Umstellung auf 100 % erneuerbare Energien möglicherweise nicht oder nur langfristig möglich ist, andere Technologien zur Dekarbonisierung der Brennstoffnutzung (z.B. Technologien zur Kohlenstoffabscheidung) einen wichtigen Meilenstein auf dem Weg zu 100 % erneuerbarer Energie darstellen.

Gebäude stehen im Fokus des Klimaschutzes in Regionen, die entweder eine hohe Urbanisierungsrate aufweisen, wie in AP, oder in denen die Gebäudestandards für Energie- (und Material-) Effizienz niedrig sind oder fehlen. In diesem Zusammenhang scheint die Nutzung erneuerbarer Energien zur Deckung des Heiz- und Kühlbedarfs von zentraler Bedeutung zu sein. Auf der anderen Seite werden Gebäude in vielen Regionen nicht als Schwerpunkt im Hinblick auf den Ressourcenschutz betrachtet, obwohl die Verwendung von Rezyklaten aus Bau- und Abbruchabfällen von einigen Befragten als relevant angesehen wurde. Wo jedoch, wie in den USA, eine große Grundfläche bzw. Gebäudefläche pro Person ein Thema ist, werden auch im Gebäudesektor Veränderungen des Lebensstils und der Suffizienz zum Thema.

Darüber hinaus erscheinen Veränderungen und Anpassungen in Lebensstilen sehr vielversprechend, sind aber in der gegenwärtigen politischen Ökonomie und gesellschaftlichen Debatte nur schwer durchsetzbar. Kultur und Tradition wirken solchen Veränderungen entgegen, insbesodere wenn man den Fleischkonsum als ein (aufkommendes) kulturell tief verwurzeltes Statussymbol betrachtet. Die Ernährung erweist sich jedoch als ein Schwerpunkt sowohl des Klimaschutzes als auch der Ressourcenschonung, und sowohl in der jüngeren als auch in der städtischen Bevölkerung zeigen sich Trends zu nachhaltigeren Lebensstilen, z.B. vegetarische und vegane Ernährung. Dies ist zwar in keiner Region Mainstream, aber die Befragten schlugen vor, populäre oder religiöse Vorbilder zu nutzen, um solche Veränderungen anschlussfähig und glaubhaft zu machen. Ein ähnlicher Ansatz könnte erprobt werden, wo die Tradition die Erzeugung von Lebensmittelabfällen fördert, weil kulturelle Prägungen es fördern, mehr Essen zuzubereiten und zu servieren als gegessen werden kann (z.B. in AP).

Obwohl der Klima-Ressourcen-Nexus in den Interviews nicht im Vordergrund stand, wurden wesentliche Aspekte der Literaturanalyse in den Interviews ebenfalls angesprochen, u.a.:

a) Eine Lebenszyklus-Perspektive ist erforderlich, um zu beurteilen, ob der Umstieg auf erneuerbare Energien und der Ausbau der Elektrifizierung im Hinblick auf den (kritischen) Rohstoff- und Infrastrukturbedarf insgesamt Vor- oder Nachteile für Umwelt und Klima bringt.

b) Durch eine gesteigerte Nutzung von Sekundärmaterialien in allen Industriezweigen und bei den Verbrauchern werden auch der Energiebedarf und die THG-Emissionen verringert.

1 Introduction

1.1 Background

Climate protection is one of the most important, if not the most important, contemporary environmental policy issues, both on the national and the international level. The 2015 "Paris Agreement[1]", in which the signatory states committed to limiting global warming to well below two degrees (aiming for 1.5 degrees), marked a great international success for climate protection. With signing the Paris agreement, the signatory states promised national contributions to climate protection (Nationally Determined Contributions, NDCs) in order to prevent the concentration of greenhouse gases in the atmosphere to rise further. The fact that industrialised, developing and newly industrialising countries jointly committed to achieve this goal was seen as a breakthrough. However, this initial success has been dampened in recent months, for instance due to the USA's withdrawal from the agreement. Furthermore, analyses of existing NDCs have revealed a large gap between the necessary and the expected reductions in greenhouse gas (GHG) emissions through the implementation of the NDCs (UNEP 2017a). Hence, there is a clear need to step up action to foster climate protection.

According to the International Resource Panel (IRP), more than 50% of total GHG emissions are made up from natural resource extraction and processing (IRP 2019). Against this background, resource conservation and circular economy policy holds promising potential for reducing GHG emissions on a global level, and hence for climate protection. Saving on the use of primary raw materials, e.g. through recycling, has the potential to reduce greenhouse gas emissions. For instance, the energy requirement for the production of zinc from scrap metal (secondary zinc production) requires only about 5% of that needed for the extraction and production of zinc from mining and metal processing (primary zinc production) (Grund 2015). This can save up to 99% of greenhouse gas emissions associated with primary production (Lutter et al. 2016). In addition, lightweight construction methods not only reduce the need for raw materials, but also save energy that would have been needed during mining and transport. Successful climate protection policy that leads to a reduction in demand for certain products – for example, reduced individual car traffic – reduces the demand for vehicles and thus for raw materials such as iron and aluminium.

In contrast to international climate policy, there is no international policy regime for resource conservation or circular economy. But the topic is gaining in importance internationally. In the recent past, resource conservation and circular economy have been increasingly addressed in G7 and G20 meetings. The quadrupling of global resource consumption since the 1970s and the associated environmental impacts (e.g. in the extraction of raw materials) call for further need for action (IRP 2019). While challenging, the implementation of resource policies brings clear benefits: Cost savings for companies, reduced import dependency and increased employment. There are many examples worldwide of resource efficiency improvements in various sectors of the economy. International resource policy should learn from these examples and help transfer them to other countries and contexts (OECD 2016).

During G7 and G20 talks, the importance of resource conservation as a relevant strategy for achieving climate goals has been stressed. However, this recognition is relatively new at the political level and has been put on the political agenda only recently by the Intergovernmental Panel on Climate Change (IPCC 2014) and the IRP (IRP 2015, UNEP 2017b). The IRP considers

[1] See https://unfccc.int/sites/default/files/english_paris_agreement.pdf, URL accessed March 16, 2020

"*improving resource efficiency […] indispensable for meeting the costs of climate targets cost-effective*"[2] and "*increasing material efficiency […] [as] a key opportunity to move towards the 1.5° C goal set by the Paris agreement*" (IRP 2020: 7).

Despite this encouraging development, interactions between climate and resource policy – the so-called "climate-resource-nexus" – still need to be much better understood and systemically analysed. So far, the climate-resource nexus has mostly been explored from a scientific perspective, which mainly centred on the Global North. Furthermore, potentially relevant policy measures for climate protection and resource conservation appear to be developed under a Eurocentric perspective. In order to advance the understanding and consideration of the climate-resource nexus on a global level, it is of great importance to expand the geographic focus of such measures and analyse more closely their fit and implementability in various world regions. Hence, further perspectives from the Global South are needed to better understand how these policy fields and their interrelations can be configured in different contexts.

1.2 Objective and methodology of the study

Against this background, as part of the ICARE-project (Interactions between international measures for Climate Action and Resource Efficiency) this study aims to

3. Investigate key findings on the climate-resource-nexus from literature
4. Identify international measures for climate protection and resource conservation and analyse these as regards
   i. possible interactions (synergies and trade-offs) between them,
   ii. their potential relevance and fit for different world regions.

The findings shall help to improve our understanding of the "climate-resource-nexus" and expand knowledge on what kinds of climate protection and resource policy measure could be relevant in which parts of the world. Furthermore, we will use these findings to enhance the robustness of assumptions going into the quantitative analysis of the potential effects of these measures on global resource use and greenhouse gas (GHG) emissions via the System Dynamic GEE(R) model[3].

For (1.) the **literature search on the climate-resource-nexus**, we initially used ScienceDirect, the library portal "Primo" of the Freie Universität Berlin and Google Scholar. We limited our search to the years 2010 – mid 2019. As search strategy, we used the following search strings in both German and English (only English terms listed here) by means of Boolean operators:

[2] See https://www.resourcepanel.org/reports/resource-efficiency, URL accessed 8 November 2019.
[3] „Das *GEE(R) Modell' zum globalen Ausbau der Erneuerbaren Energien und seiner Rohstoffinanspruchnahme", FKZ 3716 32 100 0

- ("resource efficiency" OR "resource conservation" OR "resource scarcity") AND ("climate protection" OR "climate mitigation" OR "climate abatement") AND (nexus OR link OR interplay OR interaction OR interdependency);
- ("climate protection" OR "climate mitigation") AND ("raw materials" OR "metals" OR "minerals") AND ("trade-offs" OR "synergies" OR nexus);
- ("material footprint" OR "material use") AND ("low carbon" OR "climate mitigation" OR "carbon footprint" OR "clean technology") AND (nexus OR interplay OR interaction);
- ("circular economy" AND ("low carbon" OR "climate mitigation" OR "carbon footprint") AND (nexus OR interplay OR interaction OR synergy OT trade-off).

We then screened the titles and abstracts of the research that the search process yielded for relevance regarding interactions between climate protection and resource conservation, i.e. along the following questions:

1. Are both resource and climate protection a central issue in the publication?
2. Is the relationship between resource and climate protection described (e.g. as synergy, conflict of objectives, dynamics...)?

Publications fulfilling both criteria we included into a short list of most relevant publications. We applied the snowball system approach, i.e. using the references of articles identified by the above search process, to identify further relevant research.

For (2.) **the identification of international measures for climate protection and resource conservation**, we used experience from past and ongoing projects as well as literature review regarding relevant policy levers. This resulted in a mind map that contained a series of policy interventions, which varied in their level of specificity and sectorial relevance. We then clustered these into macro-level, more general policy measures in contrast to single policy instruments. We understand "measures" as more overarching areas for policy intervention to pursue certain policy objectives, for which different policy instruments (i.e. concrete implementation approaches, for instance a tax for CO_2 or single-use plastics) are needed. To exemplify this: a possible policy measure could be "raising prices of fossil fuels or of virgin raw materials"; to achieve creating such a negative economic incentive for more resource consuming/ GHG emitting activities, a combination of instruments can be used, including the use of taxes, e.g. a tax for CO_2 or a material input tax.

We then described the measures in further detail regarding their focus, intervention mechanism (e.g. providing incentives or knowledge, using coercion) target groups, possible instruments, as well as potential general challenges. By discussing these with experts from the German Environment Agency and considering potential fit of these measures to different world regions, we arrived at six measures for climate protection (see chapter 3.1 for a brief description) and eight measures for resource conservation (see chapter 3.2 for a brief description).

Depending on the regional particularities like governance structures or culture, the focus and prioritisation of the measures can vary, as well as the set of instruments potentially serving for implementing the measures. Therefore, we then used the measures identified for the preparation of semi-structured interviews with regional experts on regional relevance, fit and specificities of the measures.

For the interviews, we prepared two separate questionnaires for use in two parallel rounds of interviews, one focusing on climate protection experts on regional level, one on resource conservation experts on regional level. In the questionnaire questions (see the list below), we also integrated a question on the climate-resource-nexus (see question 4. of the list below), i.e. asking if the measures discussed could impact resource use / GHG emissions in their regions:

1. Do you consider the following (six/eight) measures relevant (to reduce GHG emissions/ foster resource conservation) in your region? What are the challenges and benefits of each measure in general and for your region?
2. Based on your regional experience and overview, do you see any measure(s) missing that could significantly strengthen climate mitigation/sustainable material use in your region?
3. Which measures, from the ones we presented and the ones you added, would you consider to be the top 3 "measures" in terms of their potential (to reduce GHG emissions/ strengthening sustainable material use) in your region?
4. What impacts would the measures have on resource use (in your region)/greenhouse gas emissions (climate change)?

Our target group were official experts working formally in multilateral UN institutions in the different world regions and have expertise either on resource conservation or climate protection. We searched for potential interviewees in the following regions: (Sub-Sahara) Africa, Asia-Pacific (AP), Latin America and the Caribbean (LAC), Middle East and North Africa (MENA), and North America (NA).

While initially we aimed at conducting around eight interviews with experts from UN institutions, identifying, obtaining contact data and getting interview consent from UN experts turned out to be a challenge. After several rounds of telephone and email contacts, including asking recipients for alternative or additional expert recommendations, we could secure interviews with UN institutions for Africa, Asia-Pacific and Latin America and the Caribbean. After consulting with the German Environment Agency, we turned to environmental NGOs and academia to cover further regional contexts. Eventually, we thus were able to conduct eight interviews for climate protection (covering the regions AP, LAC, MENA, and NA as well as the sub-regional level for Southern Africa) and five for resource conservation (covering the regions Africa, AP, LAC, MENA and NA). For specific findings about relevant context conditions potentially affecting climate protection and resource conservation policies in these regions, please see Chapter 0.

The interviews were recorded and used to elaborate a summary of the conversation and the interviewees were asked whether they would like to validate the summaries. These summaries served as the basis for analysing the relevance, challenges, opportunities, potential foci of measures in the different regions, as well as gaps in the currently proposed measures. Moreover, the empirically gained information has been used to assess, to the extent possible, the synergies that measures of climate protection can have with resource conservation and vice versa.

The present report is structured as follows: Chapter 2 presents key findings from the literature review on the climate-resource-nexus. Chapter 3 serves to present the measures identified and the key findings from the interviews. Chapter 3 ends with an analysis of the interactions between climate and resource measures from the insights gained through the interviews. Chapter 4 then concludes with key lessons learnt of this study and how they fit into the next steps of our research in the ICARE project.

2 The climate-resources nexus in the literature

The aim of our literature analysis was to explore the recent scientific discussion on the interactions between climate and resource policy. In particular, we wanted to find out how potential interactions are described – as synergies, trade-offs, limitations, dynamics or otherwise? We considered literature on the international and national level and included relevant sub-areas such as energy supply or electric mobility. The findings will support the further project work, in particular the further development of the qualitative cause-effect model that will be developed later on in the ICARE project.

2.1 Literature identified

When reviewing the collected information in the long list, our first finding was that there are three main thematic areas related to the nexus of climate and resource policies:

c) **Investigation of the resource demand of climate-friendly technologies:** Publications in this cluster usually describe the relation of climate and resource policies as a trade-off – climate-friendly technologies (like renewable energies, electric cars, etc.) on the one hand reduce greenhouse gases, but on the other hand increase the demand for raw materials, particularly metals.

d) **Potential greenhouse gas savings through resource efficiency**: Publications in this cluster usually describe the relation of climate and resource policies as synergies – measures to increase resource / material efficiency can reduce greenhouse gas emissions.

e) **The role of circular economy approaches for climate change mitigation**: Publications in this cluster usually describe the relation of climate and resource policies as synergies – circular economy strategies such as re-use, recycling and waste avoidance can help reducing greenhouse gas emissions.

A corresponding clustering of the publications in the long list proved to be helpful in order to obtain a good overview of the contents of the Nexus literature.

In the next step, we have compiled a short list of 32 relevant publications, with the aim of covering as wide a range as possible of relevant topics, sectors, author teams and geographical regions within the nexus literature (see Table 1 below).

Economic sectors covered by the publications in our short list include energy, mobility, construction, waste management and electronic equipment. In addition, two studies address lifestyles and consumer behavior. It is remarkable that most studies deal with the energy sector (15 out of 32 studies, although a number of those studies cover other sectors as well). Regarding geographical coverage, the list includes studies addressing the global, European as well as national or regional level. The latter includes Germany, China, UK, Australia, Austria and Scandinavia. A number of studies do not have a geographical focus.

Table 1: Short list of scientific publications used for analysing the climate-resource-nexus

No.	Cluster	AUTHORS	TITLE	SECTOR FOCUS	GEOGRAPHICAL FOCUS	NEXUS DESCRIBED AS
1	a	(de Koning et al. 2018)	Metal supply constraints for a low-carbon economy?	energy, mobility	global	trade-off
2	a, c	(Hodgkinson and Smith 2018)	Climate change and sustainability as drivers for the next mining and metals boom: The need for climate-smart mining and recycling	energy, construction		synergy
3	a	(Månberger and Stenqvist 2018)	Global metal flows in the renewable energy transition: Exploring the effects of substitutes, technological mix and development	energy	global	synergy & trade-off
4	a	(OECD 2019)	Global Material Resources Outlook to 2060 – Economic drivers and environmental consequences		global	trade-off
5	a	(UNEP 2015)	Green energy choices: the benefits, risks and trade-offs of low-carbon technologies for electricity production.	energy	global	trade-off
6	a	(Watari et al. 2018)	Analysis of Potential for Critical Metal Resource Constraints in the International Energy Agency's Long-Term Low-Carbon Energy Scenarios	energy	global	trade-off
7	a	(Berrill et al. 2016)	Environmental impacts of high penetration renewable energy scenarios for Europe	energy	Europe	trade-off
8	a	(Blagoeva et al. 2016)	Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU.	energy, mobility	European Union	trade-off
9	a	(Angerer et al. 2016)	Rohstoffe für die Energieversorgung der Zukunft. Geologie − Märkte − Umwelteinflüsse	energy	Deutschland + global	synergy
10	a	(Schlör et al. 2018)	The energy-mineral-society nexus – A social LCA model	energy		trade-off
11	a	(Viebahn et al. 2015)	Assessing the need for critical minerals to shift the German energy system towards a high proportion of renewables	energy	Germany	trade-off
12	a, b	(Elshkaki and Shen 2019)	Energy-material nexus: The impacts of national and international energy scenarios on critical metals use in China up to 2050 and their global implications	energy	China	trade-off
13	b	(Hatfield-Dodds et al. 2017)	Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies		global	synergy

14	b, c	(Hertwich et al. 2019)	Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics—a review	construction, mobility, electronics	global	synergy & trade-off
15	b	(van den Berg et al. 2016)	Exploring resource efficiency for energy, land and phosphorus use: Implications for resource scarcity and the global environment	energy, agriculture (land + phosphorus use)	global	synergy & trade-off
16	b	(Distelkamp and Meyer 2019)	Pathways to a Resource-Efficient and Low-Carbon Europe		Europe	synergy
17	b	(Günther et al. 2019)	Den Weg zu einem treibhausgasneutralen Deutschland ressourcenschonend gestalten	energy	Germany	synergy
18	b	(Werland et al. 2014)	Nexus Ressourceneffizienz und Energiewende. Eine Analyse der Wechselwirkungen		Germany	synergy & trade-off
19	b	(Barrett and Scott 2012)	Link between climate change mitigation and resource efficiency: A UK case study		UK	synergy
20	b	(Hammond, Howard, and Rana 2019)	Environmental and resource burdens associated with low carbon, more electric transition pathways to 2050	energy, mobility	UK	trade-off
21	c	(de Wit et al. 2019)	Circularity Gap Report	circular economy		synergy
22	c	(Jacobi et al. 2018)	Providing an economy-wide monitoring framework for the circular economy in Austria: Status quo and challenges	circular economy, energy	Austria	synergy
23	c	(Material Economics 2018)	The Circular Economy - a Powerful Force for Climate Mitigation	industry, construction, mobility	EU and global	synergy
24	c	(Cooper and Gutowski 2017)	The Environmental Impacts of Reuse: A Review	reuse of products		synergy
25	c	(Schanes, Giljum, and Hertwich 2016)	Low carbon lifestyles: A framework to structure consumption strategies and options to reduce carbon footprints	household consumption / lifestyles		trade-off
26	c	(Van der Voet et al. 2019)	Environmental Implications of Future Demand Scenarios for Metals. Methodology and Application to the Case of Seven Major Metals		global	synergy
27	c	(Huang et al. 2013)	Materials demand and environmental impact of buildings construction and demolition in China based on dynamic material flow analysis	construction	China	synergy

28	c	(Nußholz, Nygaard Rasmussen, and Milios 2019)	Circular building materials: Carbon saving potential and the role of business model innovation and public policy	construction	Scandinavia	synergy
29	c	(Aracil et al. 2017)	Proving the climate benefit in the production of biofuels from municipal solid waste refuse in Europe	waste management	Europe	synergy
30	c	(Seelig et al. 2017)	Ressourcen- und Klimaschutz durch Kreislaufwirtschaft	waste management	Germany	synergy
31	/	(Sameer and Bringezu 2019)	Life cycle input indicators of material resource use for enhancing sustainability assessment schemes of buildings	construction		trade-off
32	/	(Bleischwitz et al. 2018)	Resource nexus perspectives towards the United Nations Sustainable Development Goals			synergy

2.2 Main findings on the climate-resources-nexus

2.2.1 Cluster a: Investigation of the resource demand of climate-friendly technologies

The largest fraction of publications identified for analysis of the climate-resources-nexus can be assigned to cluster a: "Investigating the resource demand of climate-friendly technologies". This is due to the fact that in the last decade, the scientific community has intensely explored and discussed the resource demand for low-carbon technologies in order to substitute fossil fuels and to transform the energy sector. The studies address a transition towards climate-friendly infrastructures and technologies on a large scale (country, EU or even global level), typically applying scenario analysis and modelling, and mostly focus on the energy and mobility sector. Hence, studies often describe the relationship between climate and resource policies as "energy-material nexus" (e.g. Elshkaki and Shen 2019) or "energy-metal nexus" (e.g. Watari et al. 2018). Schlör et al. (2019), who describe the nexus topic as a new systems thinking approach, highlight the social dimension of the resource demand for renewable energy technologies. They emphasise that both the energy sector and the mineral sector are systems embedded in society. Therefore, the authors describe these interactions as the "energy-mineral-society nexus". Beyond this cluster, an even broader nexus concept is introduced by Bleischwitz et al. (2018). For them, the resource nexus encompasses interactions and interlinkages between water, energy, land, food and materials. Albeit they address climate mitigation only as one environmental challenge among others, they hint to synergies between climate policy and resource conservation.

The starting point and reason for most of the studies we assigned to cluster a: is the observation that the introduction of climate-friendly technologies – like renewable energies or battery-powered cars – requires a high quantity of raw materials, particularly metals. One central question in this cluster is the following: Is it feasible to implement an ambitious climate policy with modern, metal-intense technologies, or do resource constraints hinder these endeavours?

Answers to this question vary. A number of studies see the resource demand as challenging, but feasible. One of the earliest studies in our list is by Kleijn et al. (2011), who compared GHG emissions and metal requirements of different power generation technologies. The study was one of the first to point out the metal-intensity of various climate-friendly technologies compared to fossil fuelled technologies. The authors concluded that a global transition to a climate-friendly power generation would lead to a significant rise in metal demand. In their view, mining rates of various metals would need to increase substantially.

The results of Hertwich et al. (2015) point in a similar direction. Applying life cycle analysis to electricity generation by renewable energies, they note that "material requirements per unit generation for low-carbon technologies can be higher than for conventional fossil generation: 11–40 times more copper for photovoltaic systems and 6–14 times more iron for wind power plants" (Hertwich et al. 2015, 6277). The authors conclude that the material requirements are a factor that needs to be considered, yet overall they see it as "manageable" (ibid.). Furthermore, they point out that copper supply could become a concern. Similarly, de Koning et al. (2018) foresee a substantial rise in metal demand and calculate that extraction rates of various metals need to increase. Yet, comparing these future needs with historical growth rate levels of metal extractions, the authors see this still within the realm of feasibility. Nevertheless, the authors recommend to pay more attention to raw material requirements and availability, and to consider substitution of materials when possible. More specifically, they state that resource supply disruptions could become more likely in the future, for example in case that investments in new mines are not made in time, metal extractions become costlier due to lower ore concentrations, or protests against environmental consequences of mining. Such disruptions could delay the transition to a low-carbon economy.

Other studies applying modelling and scenario analysis arrive at more pessimistic results. They indicate that resource specific constraints are likely to hamper a transition to a low-carbon economy and the achievement of political climate goals. Moreover, they highlight the dependence of various low-carbon technologies on the availability of specific metals (Grandell et al. 2016; Watari et al. 2018; Tokimatsu et al. 2018). For example, Grandell et al. (2016) point out that various new, low-carbon technologies are dependent on the availability of special metals. Focusing on solar electricity, wind power, fuel cells, batteries, electrolysis, hydrogen storages, electric cars and energy efficient lighting, the authors' modelling results indicate that special metals will not suffice to realise a global energy transition. In particular, they found silver to be the most critical metal (followed by tellurium, indium, dysprosium, lanthanum, cobalt, platinum and ruthenium). Hence, the authors emphasise the need to find substitutions for critical metals as well as to find new renewable energy technologies that are not dependent on critical metals. Similarly, Watari et al. (2018) conclude that "the diffusion of solar power and next-generation vehicles may be hindered by resource depletion" (p. 25). According to their results, the resource supply of indium, tellurium, silver, lithium, nickel as well as platinum can become critical. The authors advise to implement countermeasures for these metals, e.g. recycling, increasing material efficiency, and substitution of materials or use of alternative technologies. For recycling, they see particular potential: "recycling can reduce primary demand by 20% to ~70% for low carbon energy technology" (Watari et al. 2018, p. 1).

Manberger & Stenqvist (2018) argue that most of the – often pessimistic – studies on the criticality of resources for a global renewable energy transition did not take into account that technology development is dynamic. Factoring in dynamic assumptions on material intensity over time, the authors come to a different conclusion: "The study results showed that reserves are sufficient to support the total level of solar power, wind power and electric motors. Insufficient reserves may very well constrain certain sub-technologies, but substitutes that take the role of 'back-stop' technologies can be used instead" (p. 226). As the only exception, the authors mention lithium batteries.

On the European level, Blagoeva et al. (2016) identified various metals that could become critical for a large-scale implementation of wind and photovoltaic energy as well as electric vehicles in the EU. As solutions the authors propose to increase the raw materials production within the EU, increase recycling efforts and consider substitution of materials. While these measures could avert supply risks for most metals, neodymium and praseodymium needed for electric cars would remain scarce. Berrill et al. (2016) add to the debate that apart from the high metal demand for renewable energy infrastructures, an energy transition in Europe would considerably increase the demand for land.

Looking at Germany, two studies (Angerer et al. 2016, Viehbahn et al. 2015) examine the question whether raw material deposits are sufficient to implement the energy system transformation (Energiewende). Both conclude that in principle, there are sufficient raw materials available. According to Angerer et al. (2016), the challenge will be to make the supply secure, affordable and environmentally and socially sound. Similar to several studies on the global level, the authors recommend to expand recycling capacities in order to reduce the dependency on resource imports. Viehbahn et al. (2015) classify certain sub-technologies as critical regarding their demand of neodymium, dysprosium, indium, selenium and vanadium. Yet the authors perceive that alternatives for these sub-technologies exists.

2.2.2 Cluster b: Potential greenhouse gas savings through resource efficiency

Studies in this cluster explore in what ways resource efficiency or material efficiency approaches contribute to reducing greenhouse gas emissions. While cluster b and c are somewhat similar, cluster b focuses more on industrial resource conservation through efficiency increases, and less on waste management. In contrast to cluster c, closing loops is not a central issue here in cluster b.

A number of authors hint to an apparent knowledge gap regarding the relationship between resource conservation strategies and climate mitigation, which motivated them to conduct their studies. They suspect that there is untapped potential to reduce greenhouse gas emissions by increasing resource efficiency. For example, Hatfield-Dodds et al. (2017) state that "the outlooks for and interactions between global natural resource use, resource efficiency, economic growth and greenhouse emissions are not well understood" (p. 403). Likewise, Hertwich et al. (2019) find that “emissions savings from [material efficiency strategies] remain poorly understood” (p. 1). They attribute this partly to the fact that materials are used in many different ways and under very different circumstances, but at the same time the authors point to a research gap.

Three studies used computer-based modelling to simulate the potential effects of resource efficiency approaches up to the year 2050 on a global level (van den Berg et al. 2016; Hatfield-Dodds et al. 2017; Distelkamp and Meyer 2019). All of them see high potential for resource efficiency strategies to contribute to climate change mitigation. Van den Berg et al. (2016) analysed resource efficiency approaches related to energy, land and phosphorus use and assessed their environmental effects, including on climate and resources. The researchers simulated the effects of two very ambitious resource efficiency scenarios. Their results “confirm that significant potential for resource efficiency exists. The potential is large in terms of what is physically possible and in terms of connecting resource policy with climate policy” (van den Berg et al. 2016, p. 31). Despite this positive assessment, the authors point out that there can also be trade-offs and conflicting goals. For example, a more efficient land use for farming requires higher inputs of fertiliser, which increases phosphorus use. Moreover, the authors emphasise that since resource availability and consumption differs across regions as well as across types of resources, resource efficiency effects vary significantly. Hence, they recommend to design policies that are "region-specific, resource-specific and sector-specific” (p. 21), and to adopt an integrated approach between climate and resource.

Distelkamp and Meyer (2019) used a dynamic multi-region input-output model to examine transformation pathways to achieve both climate and resource conservation. They simulated an integrated climate-and-resources policy mix which included fiscal, regulative and informative instruments. Their results indicate that in a joint global effort, such a policy mix would “allow a clear turnaround towards climate protection and a sustainable use of resources without deteriorating economic performance” (Distelkamp and Meyer 2019, p. 88). Moreover, their results demonstrate that the European Union could have a key role in initiating global efforts by being the first to implement the policies. EU Member States would benefit economically from such actions and at the same reduce negative environmental effects.

Hatfield-Dodds et al. (2017) explore how resource efficiency strategies affect both resource use and greenhouse gas emissions, while also considering effects on economic growth. Overall, the research results reveal substantial synergies and win-win situations. By means of modelling and scenario analysis, the authors illustrate that a mix of resource efficiency measures applied on a global level could reduce greenhouse gas emissions by 15-20% and resource extractions by 17% by 2050. In addition, they demonstrate that resource efficiency approaches can facilitate the transition to a climate-friendly economy by reducing the costs of climate change abatement. More specifically, the authors argue that climate protection strategies alone would reduce the

consumption of resources, but would also weaken economic growth. In contrast, resource efficiency strategies can boost economic growth, and the economic gains can offset the costs of shifting to a low-carbon society. Hence, the authors conclude that the best way to limit climate change to 2°C is to combine greenhouse gas abatement strategies with resource efficiency strategies.

One challenge that Hatfield-Dodds and colleagues point out is that efforts to enhance resource efficiency in isolation can lead to rebound effects – which can cancel out the aggregate resource savings and the associated greenhouse gas emission reductions. This is due to the fact that increased resource efficiency can affect quantities and prices of resources. Cheaper or more easily available resources in turn incentivise a higher resource consumption, if no accompanying measures are introduced. Against this background, the authors suggest to introduce a resource extraction tax. In fact, their modelling encompasses a mix of three types of measures: 1) resource innovation and improvement, 2) a resource extraction tax and 3) resource demand shifts (through regulation, planning and procurement). Those three measures together had the effect to overall increase resource prices by approx. 9% and to decrease resource extraction volumes by approx. 18% by 2050 compared to the baseline scenario.

Various other studies raise the issue of rebound effects as well (e.g. Hertwich et al. 2019; Distelkamp and Meyer 2019; Barrett and Scott 2012; van den Berg et al. 2016). Van den Berg et al. (2016) argue that rebound effects can be counteracted by combining resource and climate protection policies: “Taxation of greenhouse gases can, for example, reduce the consequences of downward impacts on prices as a result of efficiency policies” (van den Berg et al. 2016, p. 32).

A very recent literature review by Hertwich et al. (2019) also concludes that a more efficient use of resources has great potential to reduce greenhouse gas emissions. The authors analysed existing scientific publications on material efficiency approaches for buildings, automobiles and electronic equipment. Regarding the building sector, they found that a more intensive use and lifetime extension are most promising to save greenhouse gas emissions. For vehicles, lightweighting and reducing the size of cars is a good way of saving both resources and greenhouse gas emissions in countries with relatively large standard sizes. Evidence for improving material efficiency of electrical equipment was less clear. Furthermore, Hertwich et al. stress that in many cases trade-offs occur between material input in the production phase and energy consumption in the operational phase. In addition, the authors point out that more studies exist that analyse material efficiency effects in highly developed regions, while the potential for saving greenhouse gases through material efficiency approaches is likely to be higher in developing countries.

Further studies examine the relationship of resource efficiency strategies and climate policy on the national level. For example, a report by the German Environment Agency (Günther et al. 2019), presents first results of a scenario study for Germany which considers greenhouse gas neutrality and resource conservation jointly and in an integrated manner. More specifically, the "GreenEe" scenario simulation demonstrates how greenhouse gas emissions can be reduced by 95% (compared to 1990) and primary raw material consumption by 60% (compared to 2010) in Germany by 2050. Similar to the findings of the global scenario modelling studies described above, the authors conclude that a combination of ambitious climate protection and resource conservation policies helps to achieve both goals. They recommend to discuss such a systemic approach more strongly in the future.

In a further German study, Werland et al. (2014) analyse the interactions and coherence of two central environmental policy projects of the German government: the energy system transformation (*Energiewende*) and increasing resource efficiency. The authors conclude that there are mainly synergies. In particular, an overall reduction in the use of (primary) materials would generally lead to a reduced demand for energy, and would thus reduce greenhouse gas emissions. At

the same time, reducing resource consumption generally would protect the natural resources land, water, air and biodiversity. Yet, Werland et al. also show that there is potential for conflicts in specific areas. For example, the materials and processes used for lightweight construction in the automotive sector can be more resource-intensive than conventional construction methods. The energetic refurbishment of buildings requires insulating materials, which increases the resource demand. Apart from that, the authors see the material and energetic use of biotic materials as a major problem area, as the land available for their cultivation is limited. Here, the authors emphasise that while substituting limited abiotic raw materials by renewable, biotic ones seems more sustainable at first sight, the indirect environmental effects are dependent on cultivation methods and transport routes – and they are generally not yet well researched. Besides, land use changes can cause additional greenhouse gases emissions and there is a risk of land use conflicts. Hammond et al. (2019), who focus on electric transition pathways in the UK, also take a critical view of biomass use. They argue that enhanced biofuel production should not be considered a viable option to achieve climate and resource goals.

A further study that focuses on the UK and aimed to analyse the interactions of material efficiency strategies and climate change mitigation was published by Barrett and Scott in 2012. The authors compared various strategies of dematerialisation, including production-side and consumption-side measures. They found that generally consumption-side measures have a higher potential to reduce greenhouse gas emissions, as they also affect imports. Moreover, as most promising material efficiency strategies the authors identified Product optimisation, product lifetime extension and dietary changes.

2.2.3 Cluster c: The role of circular economy approaches for climate change mitigation

Publications in this cluster focus on circular economy strategies, i.e. keeping raw materials and their economic value as long as possible in the loop; or in other words, "making better use of the materials that already exist in the economy" (Material Economics 2018, p. 176). The basic assumption of the studies is that circular economy strategies do not only conserve resources but also have the potential to reduce greenhouse gas emissions. Moreover, publications assigned to this cluster pay particular attention to the issue of waste generation and examine approaches to waste prevention, such as the use of secondary materials. In contrast to the cluster b studies, cluster c strongly addresses the entire life cycle from design to waste management in the context of the circular economy. The majority of studies in cluster c: concentrates on sub-areas of the circular economy and their respective contributions to climate change mitigation, i.e. they focus on specific economic sectors (e.g. the building sector), materials (e.g. metals) or strategies (e.g. re-use).

A number of studies take a broader look at making the economy as a whole more circular. One of those is the "Circularity Gap Report" by de Wit et al. (2019). Referring to the "global metabolism", which describes the input and output of materials to serve human needs, the authors present an indicator to measure the state of circularity of the global economy. The indicator is "the share of cycled materials as part of the total material inputs into the global economy every year" (de Wit et al. 2019, p. 22). Taking into account four types of resources (minerals, fossil fuels, metal ores and biomass), the report states that in the year 2015, overall materials inputs amounted to 92.8 billion tonnes globally. Of these, only about 8.4 billion tonnes counted as "cycled materials" (reused or recycled), while 84.4 billion tonnes were extracted resources. Hence, the authors conclude that only 9.1% of the global economy was circular. They emphasise that these numbers point to a significant untapped potential to save resources – and, along with this, greenhouse gases. More specifically, the authors argue that through a more circular economy, overall less resources need to be extracted, processed and transported, and in each of these

steps climate gas emissions can be saved. In addition, emissions related to the waste management phase can be reduced. De Wit and colleagues summarise that a circular and a low-carbon economy are "complementary and mutually supportive" (de Wit et al. 2019, p. 8). They even argue that a climate goals of the Paris Agreement could not be reached without making the economy more circular, as a large share of global greenhouse gas emissions are related to material management.

A study by Jacobi et al. (2018) also hints to a great potential to save greenhouse gases through strengthening the circular economy. The authors argue that research on the environmental effects of the circular economy has so far often been restricted to the level of products and firms. To further advance research, the authors established a nation-wide monitoring framework to examine the state of the circular economy. They applied it to Austria, analysing and combining data on material flows, waste generation and greenhouse gas emissions. With this, they also aimed to gain new insights into the interplay between the circular economy and climate protection. The findings of Jacobi et al. show that the circular economy can save considerable amounts of energy compared to the use of primary resources. However, the authors point out that there are exceptions, i.e. that recycling of certain materials (e.g. metal alloys) or complex products can be very energy-intense. In such cases recycling only has a positive effect if energy production is de-carbonised. Hence, the authors argue that establishing a climate-neutral energy system should have priority. In their global literature review, Hertwich et al. (2019) also addressed the current challenges to recycle complex products. They argue that "higher collection rates, sorting efficiencies, and the alloy-specific sorting of metals to preserve the function of alloying elements while avoiding the contamination of base metals are important steps to further reduce emissions" (Hertwich et al. 2019, p. 1).

A report by Material Economics (2018) frames the circular economy as "a powerful force for climate mitigation." The authors explore how circular economy strategies can help saving greenhouse gas emission from the heavy industry. They focused on steel, plastics, aluminum and cement. Based on scenario modelling, the authors estimate that up to 296 million tonnes of CO_2 per year could be saved in the EU by 2050, and on the global level up to 3.6 billion tonnes. In line with these findings, Van der Voet et al. (2019) state that regarding the future demand of metals and associated greenhouse gas emissions, "by far, the most effective option for all metals appears to be to increase the share of secondary production" (p. 1).

Seelig et al. (2017) equally emphasise the role of the circular economy to conserve resources and protect the climate at the same time. Looking at the circular economy from an engineering perspective, the authors examined waste management in Germany. They argue that an increased material recycling would have a positive impact on supply security, energy consumption and environmental impacts. To achieve this, they see the waste sector as a key player who can enable a circular economy by improving separate collection and preconditioning of waste. Aracil et al. (2016) also see potential for the waste sector to contribute to climate mitigation. The research group concentrated on a particular waste stream: the non-recyclable part of municipal solid waste, which in their view "represents an important untapped resource for biofuel production in Europe" (Aracil et al. 2017, p. 2887). Municipal solid waste may be a good alternative to using food crops for biofuel production, as the latter is often related to critical land use changes and land use conflicts (as illustrated by Werland et al. 2014; Hammond et al. 2019 – cf. chapter 2.2.2). The study shows that producing biofuels from non-recyclable municipal waste has clear climate benefits compared to incineration.

Regarding the building sector, Huang et al. (2013) explored how prolonging the lifetime of buildings and enhancing recycling of construction materials affects the emission of greenhouse gases in China. By means of material flow analysis, the authors examine resource needs and environmental impacts. Background of this study is that large scale building projects in China have been

resource intense and caused considerable environmental pressures. The research team led by the School of Earth and Environmental Science in Lanzhou concludes that prolonging the lifetime of buildings as well as enhancing materials recycling generates benefits for both climate change mitigation and resource conservation. Nußholz, Nygaard Rasmussen and Milios (2019) come to the same conclusion about recycling of construction materials, albeit through a completely different research approach. They investigated three case studies of companies that produce building materials with secondary material input in Scandinavia and estimated the respective potential to save greenhouse gases. Each company specialised on a different type of building material: the first on wood-plastic composites, the second on secondary concrete and the third on re-use of bricks. The authors found that in all three cases a considerable amount of emissions can be saved compared to the production of new materials of the respective type. In addition, Hertwich et al. (2019) found that recovering base metals from construction and demolition waste and bringing them back into the economic cycle can reduce greenhouse gas emissions significantly. Sameer and Bringezu (2019), who also looked at the building sector, see a risk that currently sustainable construction designs focus only on saving greenhouse gases while neglecting the potential to also save resources. They call for a combination of climate protection and resource conservation strategies in the design of buildings.

The role of consumers in reducing both resource consumption and greenhouse gas emissions is addressed in two studies from our short list. First, Schanes et al. (2016) analysed consumer practices and their related greenhouse gas emissions in a systematic way. Considering a wide variety of consumer practices (including, e.g., consuming less, choosing more sustainable products and services, re-using and sharing), the authors found that emission reductions achieved by a certain practice are often offset by emission increases through another type of practice. Also, emission savings can be overcompensated by additional consumption (i.e., rebound effects). In view of these findings, the authors see it critically that current policy-making as well as research on the consumption side often focuses solely on improving resource efficiency and saving energy. They conclude that despite the trade-offs pointed out, there is potential to save greenhouse gas emissions through changes in consumer behaviour. This lies in adopting and supporting circular thinking and a sharing economy. Second, Cooper and Gutowski (2017) reviewed literature on the re-use of products and the related environmental effects. They conclude that synergies as well as trade-offs exist. While the reuse of various types of products requires less energy input than new production, Cooper and Gutowski found that "reusing an item does not guarantee environmental benefits" (p. 1) in all cases. This applies in particular to powered products with long product life when more energy-efficient new products are available. The study shows that although re-use should be preferred over recycling according to the waste hierarchy, in certain cases recycling or preparing components for re-use is the climate-friendlier option.

2.2.4 Key actors in the research on the climate-resource-nexus

The reviewed publications show that so far relatively little research has been conducted to illuminate the interactions between resource conservation and climate protection. Hence, various uncertainties and knowledge gaps remain. Regarding the studies presented above, it is estimated that overall there is a high potential for synergies between resource conservation and climate protection – especially if both policy areas are well coordinated. Yet, a number of trade-offs also exist for certain product groups and materials. In particular, the large-scale implementation of climate-friendly technologies in the energy and mobility sector is very resource-intense, and the availability of certain resources can become a challenge that requires careful attention. Overall, the publications give strong support for recycling and the use of secondary materials as a way to save both resources and greenhouse gas emissions.

In our literature search, we have paid attention to including a broad spectrum of institutions that publish reports or scientific articles on the resource-climate-nexus. First, we focused on the German research landscape to identify the state of discussion from a German perspective. Within Germany, we identified the following research institutions that have built up expertise on the resource-climate-nexus:

- Fraunhofer-Institut für System- und Innovationsforschung – ISI
- Center for Environmental Systems Research (CESR), University of Kassel
- CUTEC Clausthaler Umwelttechnik Forschungszentrum
- Gesellschaft für wirtschaftliche Strukturforschung - GWS, Osnabrück
- Freie Universität Berlin

Next, our literature review covered research conducted in various other European states. Institutions with particular expertise in resource conversation and climate change include the following:

- **In the Netherlands:** PBL Netherlands Environmental Assessment Agency; Institute of Environmental Sciences (CML) – Leiden University; Circle Economy in Amsterdam
- **In the Scandinavian countries:** Department for Environmental and Energy Systems Studies at the Lund University; Material Economics (consultancy firm) in Stockholm; the Industrial Ecology Programme and Department of Energy and Process Engineering at the Norwegian University of Science and Technology (NTNU)
- **In the United Kingdom:** Sustainability Research Institute at the University of Leeds Bartlett School of Environment, Energy and Resources, University College London
- **In Austria:** Institute of Social Ecology (SEC) at the University of Natural Resources and Life Sciences in Vienna; Institute for Ecological Economics at the Vienna University of Economics and Business (WU)

Beyond Europe, we identified experts on the resources-climate-nexus in Australia, Japan, the USA and China. From this we draw the conclusion that most research institutions that address the resource-climate-nexus are based in industrialized countries. Central institutions to be mentioned here are the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, the Graduate School of Energy Science at the Kyoto University in Japan, the Institute of Geographic Sciences and Natural Resources Research (IGSNRR) at the Chinese Academy of Sciences, and the School of Forestry and Environmental Studies at the Yale University as well as the Massachusetts Institute of Technology in the USA.

In addition, there are supranational institutions that publish reports on the nexus topic. These include the OECD and the International Resource Panel (UNEP) on the global level as well as the Joint Research Centre (JRC) in Europe.

3 International measures for climate protection and resource conservation – potentials and interactions

This chapter first gives on overview of policy measures for climate protection and resource conservation on an international level (see subchapters 3.1 and 3.2). We identified six measures for climate protection and eight measures for resource efficiency as most relevant for reducing greenhouse gas (GHG) emissions and for increasing resource efficiency and moving to a circular economy on a global level.

Secondly, we present key findings from expert interviews regarding the measures' potential and relevance for different world regions (see subchapters 3.3, 3.4 and 3.5). Finally, we provide an overview of regional perspectives (see subchapter 0) and a brief synthesis in terms of potential interactions between climate protection and resource conservation measures (the so-called 'climate-resource-nexus', see subchapter 3.7).

3.1 Measures for climate protection

Based on past project expertise and literature review, we identified the following six measures for climate protection as most relevant for reducing GHG emissions on a global level.

- **Measure 1 – Shifting to 100% Renewable Energy**

Renewable energy sources supply all energy such as electricity, heating and cooling as well as fuels and gases. This also includes a change in technology and infrastructure use to support renewable energy utilisation such as electricity grids, gas networks, heat infrastructure and energy storage systems.

- **Measure 2 – Increasing Electrification**

Electrification across all sectors reduces the direct use of fuels, which are currently mainly fossil fuels. This includes power to heat (e.g. heat pumps), and electrification of transportation and of industrial processes. It also includes the use of electricity to generate fuels (power-to-gas; power-to-liquids). Using electricity in various sectors in an integrated approach (e.g. physical linking of infrastructures, new institutional or organisational integration) is also known as sector coupling. Electrification as a means of climate mitigation depends on a 100% renewable electricity (see first measure).

- **Measure 3 – Shifting to Zero-Emission Buildings**

The measure yields at a high renovation rate with deep energy-oriented modernisations in the existing building stock as well as implementing zero-emission standards for new buildings. Renewable energies will provide direct and indirect energy consumption, e.g. electricity or heating/cooling. It also includes the use of low-emission construction materials.

- **Measure 4 – Reducing Fertilizer Use and Liquid Manure Input on Fields**

Reducing the use of fertilizers and liquid manure in the agriculture sector reduces direct and indirect emissions of methane (liquid manure) and nitrous oxides (liquid manure and mineral fertilizers), which are potent GHGs. This measure includes the option of manure pre-treatment in biogas facilities as well as change in agricultural practices including organic farming.

- **Measure 5 – Changing Life-Styles and Sufficiency**

Global consumption patterns have a high impact on GHG emissions and there is an urgent need for change. This includes in particular a dietary change towards a more plant-based diet. Changing lifestyles and sufficiency approaches require social acceptance. Education and awareness do open alternatives.

- **Measure 6 – Increasing Natural Carbon Sinks**

The measure aims at increasing natural carbon sinks and efforts to raise climate mitigation through land use, land use change and forestry. A focus is on the protection of forests and their economic use.

3.2 Measures for resource conservation and for moving to a circular economy

Based on past project expertise and literature review, we identified the following eight measures for resource conservation and moving fostering a circular economy on a global level.

- **Measure 1 – Setting a global per-capita resource use budgets**

Global levels and resource use and increasing scarcity of some raw materials sparked a discussion whether global per-capita resource use budgets could be set. These budgets need to account for environmental justice, for instance by balancing historical consumption in the Global North and South. Developing an international convention for resource conservation could be a means to negotiate and implement such a budget.

- **Measure 2 – Raising prices of virgin materials**

Material prices reflect the value a material has for users. Relatively higher primary material prices can incentivise a more thoughtful, more sustainable use of materials, such as using secondary instead of primary materials.

- **Measure 3 – Fostering markets for sustainable products and secondary raw materials**

Resource conserving products and services, as well as secondary raw materials often lack a proper market. Therefore, demand is rather low and prices are relatively high, which hampers further uptake and diffusion of such products and secondary raw materials. The measure aims at creating a market for secondary raw materials.

- **Measure 4 – Designing products and business models for material efficiency and long service life**

The design of products, production processes and business models largely determines the amount of primary raw materials needed for them. Therefore, design considerations regarding material selection, material efficiency in production and extended life-time of products are crucial for reducing raw material needs. Also, innovative business models can reduce material use by design.

- **Measure 5 – Making re-use and repair of products easier and more attractive**

Re-using and repairing products can make their service life significantly longer. However, repair options are scarce and expensive as well as spare parts and incentives for product re-use are

missing. The measure aims at incentivising repair and re-use of products, with a particular focus on electronic devices. The measure aims at fostering material-efficient design of products, processes and business models.

- **Measure 6 – Reducing plastic waste**

Plastics serve many different functions and find their way into increasingly diverse applications in many sectors, including packaging, cosmetics and care products, automotive industry, the building sector and also agriculture. This has caused a steep increase in plastic production worldwide throughout the last five decades, mostly of single-use packaging and utensils that get disposed of quickly. Linked to this increased plastic production is a growing accumulation of plastic waste which often enters directly the environment, for instance by littering. Such an uncontrolled plastic pollution is associated with a variety of negative impacts for the ecosystem. Moreover, a common management strategy for plastic waste is incineration, which causes an increase in GHG emissions as plastics are largely fossil-fuel based (petrol derivate). Therefore, the measure is aimed at reducing plastic quantities considerably along the entire value chain, thus contributing to lowering the need for virgin plastics and its associated GHG emissions.

- **Measure 7 – Making the built environment more material efficient**

The built environment is increasing exponentially worldwide and the construction sector accounts for one of the largest material consumption worldwide. Therefore, reducing the amount of primary construction materials offers a significant potential for reducing resource use, for instance through an improved use of construction and demolition waste (CDW) as a raw material. The measure aims at either increasing material efficiency in buildings or incentivising the use of recycled construction materials, e.g. reducing hazardous material content in construction materials, creating quality standards of recycling construction materials, etc.

- **Measure 8 – Creating a sustainable food system**

One of the biggest challenges of sustainability in light of continuous population growth is achieving food security without depleting resources such as land and water beyond the planet's carry capacity. The measures aims at creating a food system that reduces the need for water, land and agrochemicals, while at the same time feeding the population in a healthy way (e.g. by using more plant-based diets or reducing food waste).

3.3 Expert interviews with representatives for different world regions

In order to collect feedback on the perceived relevance and fit of the above measures in different world regions, we conducted telephone-based and online interviews with experts from UN institutions, environmental NGOs and academia in the world regions Africa, Asia-Pacific, Latin America and the Caribbean, Middle East and North America.

Table 2 shows the institutions that we interviewed per topic in the different world regions.

Table 2: Institutions interviewed per topic in the different world regions

Organisation	Region (specific country focus, if any)
Topic: climate protection	
The African Climate and Development Initiative (ACDI) / University of Cape Town	Africa (South Africa and Southern Africa)
Greenpeace East Asia	Asia-Pacific (China)
UN Environment	Asia-Pacific

Organisation	Region (specific country focus, if any)
UN Economic and Social Commission for Asia and the Pacific ESCAP	Asia-Pacific
WWF Mexico	Latin America and the Caribbean (Mexico)
UN Environment	Latin America and the Caribbean and Africa (North Africa)
King Abdullah Petroleum Studies and Research Center (KAPSARC)	Middle East (Saudi-Arabia)
Ecologic Institute US	North America (USA)
Topic: resource conservation	
UN Environment	Africa
UN Economic and Social Commission for Asia and the Pacific ESCAP	Asia-Pacific
UN Environment	Latin America and the Caribbean
Center for Environment and Development for the Arab Region and Europe (CEDARE)	Middle East and North Africa
World Resources Institute (WRI)	North America (USA)

Source: own presentation

Please note, that the views expressed by the interviewees are their personal statements and do not reflect the position of the related institution. For an assessment of potential limitations of our chosen interview approach, please see chapter 3.8.

3.4 Key findings for climate protection measures

In the following, we present key findings from the eight interviews for each of the measures, structured along the measure's potential relevance as well as potential challenges for regional fit or applicability. This subchapter concludes with an overview of potential blind spots that interviewees saw in relation to the climate protection measures discussed in the interviews.

3.4.1 Measure 1 – Shift to 100% Renewable Energy

All interviewees considered increasing the share of renewable energy to 100% as part of the top 3 measures for reducing GHG emissions in their region, about half of the interviewees placed it first. Despite its relevance, the challenges and benefits for the installation of renewable energy differ for each region.

All regions seem to have large potential for renewables, which they have not fully explored yet. Inexpensive and easily available fossil fuels often pose strong competition; in some cases in the form of oil and gas, in others through coal. Despite decreasing investment and operational costs of renewables, the infrastructure and political systems in the regions favour fossil fuels over renewables. Moreover, emotional or historical attachments to a certain energy source and a lack of knowledge maintain the status quo.

In low- and middle-income countries (except for China), financing the renewable-energy transition is a challenge. Often the electrical grid is not built to accommodate a large share of renewables, which would require additional infrastructure investments. This seems particularly relevant in Africa compared to Latin America and the Caribbean. Nevertheless, low- and middle income countries are increasingly picking up on renewables.

China undertakes large investments in renewable energy, which drives down costs. However, the country still relies on coal power due to its large and increasing energy needs. In South Africa, unemployment and the threat of increasing unemployment keep the country attached to coal power, despite its decreasing economic feasibility.

In Central America, as well as in parts of Asia, the trade-off between land-use to produce renewables versus food poses a challenge. Ensuring food security for the population has a higher priority than, for example, producing solar energy or biofuels.

Some interviewees mentioned that it is important to take into account the full life cycle of different energy sources when analysing associated GHG impacts. This includes, e.g., the raw materials needed for production of the installation as well as leakage of emissions during fossil fuel extractions and transmission. In some cases, interviewees mention that a shift to 100% renewable energy might not be feasible. For example, the interviewee from Saudi-Arabia also sees an important role for carbon capture technologies.

The shift to a 100% renewable energy is a key measure as it has the potential to significantly reduce GHG emissions; however, full implementation is currently regarded as unrealistic due to economic and cultural restraints.

3.4.2 Measure 2 – Increasing Electrification

Most interviewees find that increasing electrification is a relevant measure, with four interviewees placing it in their top 3. Full electrification is not a goal and also seems not feasible.

In most parts of the world, increasing electrification refers to connecting households, industry and the service sector to the existing electricity grid as well as shifting to new technologies that use electricity instead of another energy carrier. In several regions, electricity outages are common due to grid and power supply bottlenecks while at the same time these regions also experience an increase in energy demand. Some interviewees mentioned that storage technology has to be further developed to make this measure feasible.

Another challenge is missing infrastructure for the electrification of some sectors, such as the transport sector. As with renewables, electrification faces strong competition from existing fossil fuel supply and related infrastructures. However, for many regions increasing electrification – in areas not connected and of sectors currently depending on (imported) fossil fuels – is also a way of increasing energy security and reducing import dependency.

In the US, the railway sector still mainly uses diesel. Thus, a shift from road to rail would not necessarily lead to a higher rate of electrification if the railway system is not electrified. China is seeking an aggressive shift to electrification in the transport sector. The country views this as a possibility to gain a competitive advantage for future economic opportunities. However, electrifying the industrial sector – predominantly steel and glass – proves more difficult and is currently not a political priority. There is political consensus in China that in the future electricity will play a large role in supplying energy to the economy. In Mexico, there is public interest in electrification, but there is no regulatory framework to support it. Market opportunities are recognised, but at the moment investments needs are considered to be too high to implement this measure.

It was also mentioned that technologies perform differently in the different regions. For example, in Saudi Arabia, batteries have a shorter life span due to generally high temperatures during the day.

The building sector seems generally less relevant for increasing electrification. For example, in Saudi Arabia, the focus is on clean thermal technologies instead of electrification and in North Africa, it is the use of waste heat.

Electrification is a relevant measure, which is closely intertwined with 100% renewable energy. However, increased electrification would put additional pressure on the electrical grid, which in many regions is often already at its maximum capacity.

3.4.3 Measure 3 – Shifting to Zero-Emission Buildings

Generally, interviewees underline the shift to zero-emission buildings to be relevant, in some cases extremely important. Two interviewees placed this measure in their top 3.

Many aspects are mentioned in relation to transforming the buildings sector, such as construction, renovation, procurement and standards. The landlord/tenant–dilemma[4] seems relevant in most cities. Rapid urbanisation and an increase in heating and cooling needs pose a challenge to most regions.

In Africa and Asia, as well as in the US, there is a strong need for energy efficiency standards in new buildings. In North Africa, the largest challenges encompass raising awareness on the need for standards and covering the increased investment costs for this measure. In Asia, greenwashing is a risk. Additionally, innovation in the usage of heating and cooling is necessary to meet the increasing demand. Here, a solution combining renewable energies with heating and cooling could be beneficial.

In the US, buildings are generally built with relatively large areas per person, leading to a higher energy consumption. Buildings are also of low quality and as a result have a relatively low life span. There is an urgent need for standards on construction and energy efficiency. However, due to low energy costs, there is no incentive for introducing these standards, renovating existing building stock or building new low-emission buildings.

China excels at implementing centralised projects, but because the buildings sector is not centralised, the introduction of zero-emission buildings faces several challenges. Due to the urbanisation rate, China is in need of a large new building stock.

The construction of buildings in Southern Africa is heavily based on cement, which is an energy and emission-intense construction material. A shift to more sustainable materials for new buildings is needed. With growing population and increased urbanisation, the buildings sector poses a big challenge to most countries in this region.

In Mexico, awareness is growing for shifting to low-emission buildings. Most new buildings, mainly in urban areas, comply with the LEED (Leadership in Energy and Environmental Design) which defines standards for highly-energy efficient, environmentally friendly, resource-saving and sustainable buildings. This measure is easier to implement for new buildings provided that information, communication and policies form a comprehensive framework. Retrofitting the existing building stock is more difficult.

Saudi Arabia has a significant potential for building retrofits. While there used to be no standards or building codes, the state has increasingly implemented some for energy efficiency and insulation. Retrofitting could be done relatively cost-efficient, at least for a large portion of the building stock. Similar to other regions, combining retrofitting with renewables could further

[4] The landlord/tenant dilemma describes a situation where the interests of landlords and tenants misalign. It is one of the key barriers for investment into the energetic renovation of buildings and apartments for rent as the landlord has to invest while the energy saving and thus cost reduction as well as the comfort gain lie with the tenant.

reduce GHG emissions e.g. through shifting to low temperature heating in combination with solar thermal energy. However, the large and increasing demand for cooling poses a great challenge to reduce GHG emissions.

Shifting to Zero-Emission Buildings is a relevant measure (for both old and new buildings), in which energy efficiency standards can play an important role. However, challenges arise from the situation that the shift is in most parts of the world not economically viable due to low energy costs and from split incentives.

3.4.4 Measure 4 – Reduction of Fertilizer Use and of Liquid Manure Input on Fields

It became evident that this measure – the reduction of fertilizers and of liquid manure input on fields –was not supported by the expertise of the interviewees since the topic was not within their field of work.

The interviewees who responded mainly recommended combining the whole agriculture sector with carbon sinks as well as adding land-use in general. Therefore, the project team decided to combine the two measures (measure 4 and measure 6) into one. The findings can thus be found below.

3.4.5 Measure 5 – Change Life-Style and increase Sufficiency

Half of the interviewees named lifestyle change and sufficiency in their top 3 measures. Most interviewees found the measure relevant, but also most difficult to implement as changing habits and consumptions patterns is a challenging field for policy making. Overall, there seems to be little awareness for this measure in all regions. Many regions have meat intensive diets interlinked with tradition and culture. Some see a change in younger generations towards greater awareness for sustainable lifestyles also in the light of increased visibility of climate impacts.

One interviewee in Asia-Pacific suggested to introduce pricing to reflect externalities of products and product lifecycles. Generally, products needs to be more sustainable. Another interviewee from Asia supported this and added innovation in agriculture, heating and cooling, such as urban food production and nature-based solutions as key prerequisites to drive lifestyle change. In China, however, there is no real ambition to start a conversation on lifestyle change and sufficiency.

In general, in Latin America and North Africa, lifestyle change and sufficiency is a very sensitive topic with cultural attachments, especially around meat consumption (but not exclusively). This is similar in South Africa. While South Africa has a relatively low consumption pattern, its economy is very energy intense. Thus, when consumption increases, emissions become significant.

In the US, many people are aware that they should do something, but the willingness to actually change habits is not there.

Mexico experiences a divide between the younger generation and the older generation. Urban young people are open to plant-based diets. To change consumption patterns that go beyond diet, safety poses a large challenge. Outside spaces are mostly unsafe, thus many young people retreat to malls and similar recreational areas, which are closely linked with consumption. If policy-makers want to induce lifestyle changes, they need to offer safe spaces. Mexico also lacks new narratives and ideas for engaging the population, which holds true especially for young people.

Changing life-styles and increasing sufficiency is a relevant measure, but also most difficult to implement as changing habits and consumptions patterns is a challenging field. In addition, in most regions safe spaces for recreation are limited to places for consumption.

3.4.6 Measure 6 – Improving agricultural practices and increasing natural carbon sinks

This measure[5] is regarded as not being very important, except for the conservation of carbon sinks, such as mangroves and forest. Two interviewees ranked the measure to increase carbon sinks in the top 3.

In the agriculture sector, the focus lays on meat production and the fast industrialisation of agriculture. Land-use and land-use change and a long trend of deforestation can be traced back to a growing population and an also growing agricultural sector. While some regions traditionally support nature conservation, economic growth is favoured over forest and other carbon sink conservation.

In China, the agriculture sector is difficult to regulate, as it is decentralised and encompasses many small farms. China is currently leading an international working group on nature-based solutions, which are meant to support the conservation and improvement of carbon sinks.

In Asia-Pacific, interviewees recommended taking a holistic view that includes looking at food waste, food consumption, health and safety. They put a focus on the negative impacts of slash and burn on the environment and the climate. A growing population leads to increased land-use for food and housing, mostly acquired through slash and burn.

South Africa has very few regulations in place for the agriculture sector. In addition, enforcement is almost non-existent. While South Africa has been able to alleviate deforestation, the situation in many other Southern African countries is worsening.

The US already has a highly clustered and industrialised agriculture sector, which is highly wasteful. Due to the country's size, there is still large potential for carbon sinks. Despite the availability of land, there is heated debate in society and politics on how it should be used. Ravaging wildfires pose additional threats to forest conservation.

In Mexico, one of the biggest challenges is the lack of a debate about sustainability in the agriculture sector. There is a high need for awareness raising to induce change. The sector is highly corrupt and corporations dictate government and farmers. In nature conservation, Mexico has improved over the last 20 years, yet there is still a constant struggle between conservation and economic exploitation. Mangroves are an important part of Mexico and Saudi Arabia's carbon sinks and need better protection.

Improving agricultural practices and increasing carbon sinks is not regarded as a key measure. This, however, might reflect the topical focus of the interviewees on other fields of actions. A key challenge for this measure is the line-up against or joining with economic activities.

3.4.7 Potential blind spots and missing measures

The project team asked interviewees to point out climate-mitigation measures –relevant to their region – that were missing from the list of selected measures.

[5] Please note: based on the responds from interviewees, the measure "increasing carbon sinks" was merged with measure 4 on agricultural practices.

Two interviewees mentioned increasing energy efficiency as a missing measure, but then basically referred to the measure shifting to zero-emission buildings. For Saudi Arabia, Latin America and North Africa there is a big opportunity for doing energy efficiency retrofits of buildings to improve efficiency of heating and cooling. For Latin America and North Africa a focus should also be on improving the energy efficiency of industry.

Rethinking and improving transport infrastructure was another measure that was brought up in two interviews. In Mexico, railway infrastructure almost does not exist, which starkly contrasts with the petrol infrastructure that is in place. In South Africa and Southern Africa, improving the urban infrastructure has the potential to reduce GHG emissions. Currently, there is a high dependency on cars. Public transport is not safe to use, as well as polluting due to the use of old buses imported from Europe. The lack of safety of public spaces was also mentioned in Mexico as a barrier to changing lifestyles.

In Mexico, the focus should be on the industry according to one interviewee. This does not constitute a concrete measure, but more of a sectoral focus. The Mexican industry contributes to one third of national GHG emissions and consumes 40% of the total electricity. By also focusing on global companies, it becomes easier to make an impact and it is a good leverage point to change the whole system.

Some of the missing measures identified by interviewees were only mentioned once, but it should be noted that this does not mean the former are not relevant for other regions. In Asia, adaptation in the context of desertification and the resulting sandstorms are becoming increasingly important, and also constitutes a way to achieve climate mitigation. In addition, slash and burn often cause haze and forest fires, resulting in a significant amount of emissions. Addressing this issue could play a big role in this regard. In China, reducing the use of coal was mentioned as an urgent measure, as coal use in China was considered “the elephant in the room”. Also, a higher efficiency in processing fossil fuels in South Africa and Southern Africa.

The eight interviews conducted with climate protection experts from different world regions revealed relevant contextual conditions, which could – or do – potentially affect, if and how climate protection policy could be implemented in the different regions. In addition to the findings shown above per climate protection measure, Chapter 0 provides a summary of key context conditions per region potentially affecting climate protection and resource conservation.

3.5 Key findings for resource conservation and for moving to a circular economy

In the following, we present key findings from the five interviews for each of the measures, structured along the measure’s potential relevance as well as potential challenges for regional fit or applicability. This subchapter concludes with an overview of potential blind spots that interviewees saw in relation to the resource conservation measures discussed in the interviews.

3.5.1 Measure 1 – Setting global per-capita resource use budgets

Interviewees considered this measure either not so relevant or completely unthinkable in the near term. It wasn’t considered in the top three by any interviewee. The interviewees were very critical towards this measure and pointed out difficulties associated with this measure. The main issues raised were related to the methodology for how to calculate it and in reaching an agreement between a large number of countries about it, particularly with consideration of the historical balance of consumption between countries of the Global North and the Global South.

At the moment, the interviewees considered it very unlikely that the (mainly developing) countries in the regions of the interviewees would agree to any kind of resource use budget. However, some possibilities for starting the discussion for such a measure were raised. For instance, if a resource budget were to be adopted by high income countries first as pioneers, it would be possible to kick start the discussion. Moreover, it was mentioned that economic incentives for encouraging developing countries to participate in such a mechanism could be effective, for instance through the negotiation of foreign debt in exchange of implementing a resource budget.

Setting global per capita budgets for resource use is considered unthinkable in the current political economy of the regions interviewed, but developed countries taking the lead by example and providing concessions to developing countries could help.

3.5.2 Measure 2 – Raising prices of virgin materials

Interviewees did not consider this measure very relevant (at least in the form of taxes) for the interviewed regions. Only one interviewee mentioned this measure among the top three.

In three regions for which interviews could be conducted, extraction of natural resources is a very important or crucial sector. For instance in Asia-Pacific (AP), the economic relevance of the extractive sector is associated with a strong political lobby. Similarly, in Latin America & the Caribbean (LAC), the sector is pivotal to the economies of the majority of countries in the region and that makes a wide range of sectors dependent on the price of the extracted raw materials. Thus, measures addressing the price of primary raw materials (particularly taxes) are in both cases very politically sensitive. In the USA and Middle East and North Africa (MENA) region taxing in general is commonly face with very low acceptance.

In AP, most countries in the region would likely face difficulties in designing and implementing primary resource taxes due to the inherent complexity involved particularly when dealing with global value chains. Moreover, difficulties in enforcement due to limited personnel or institutional capacities are likely to arise. In this context, another challenge of raising prices of virgin materials by taxation is to ensure an effective distribution of collected taxes. This implies investing the collected tax revenue for more sustainable activities and not in resource intensive activities, thus preventing the existing risk of a rebound effect. Moreover, it has been noted that raising prices for virgin materials does not necessarily lead to an increase in demand for secondary materials. These are not necessarily seen as the obvious choice if primary materials become more expensive, but the focus lies rather on extracting more or finding cheaper suppliers of virgin raw materials. Thus, implementation of this measure in AP would need to go hand in hand with Measure 3 (market of secondary raw materials). Furthermore, decision makers need to raise awareness and push forward guidelines & standards for the production and use of secondary raw materials, in order to achieve the desired effect of diversion of demand through raising prices.

In LAC, challenges are mostly related to the design of such a tax arrangement and the potential negative effects for the (international) competitiveness of the countries and uncertainties regarding the burden distribution of such measures. Thus, directly increasing the price of primary resources through a tax would not be feasible. Alternatively, the interviewee considers it more suitable to promote and financially support more sustainable products so that the price of primary raw materials increases relative to secondary resources, as circular economy and sustainable consumption & production are already gaining relevance in the region. This could be achieved, for instance, by instruments making more sustainable options easier to be identified and also relatively cheaper: fostering eco-labelling, green public procurement and extended producer responsibility policy (link to measure 3 on market of secondary raw materials).

In Africa, the primary raw materials sector is crucial for the economy of many countries and there is a general problem that mostly only the extraction and initial process take place in the countries or even the region. Thus, focus of measures regarding primary raw materials should be laid on carrying out more value-adding activities (more downstream) in the region and increasing the resource efficiency in them. This means decreasing the amount of ore and resources needed for manufacturing more refined projects (in the region) for exports.

In the MENA region, the main challenge is the public acceptance of taxes, manly related to the distribution of the burden. Some governments in the region (not specified) have reduced subsidies for instance on certain goods such as food in order to reduce consumption, but this has had issues of acceptance because such measures tend to affect mostly low income households.

In the USA working through taxes is a very sensitive issue. Therefore, the focus of working should be laid on creating a secondary materials marketplace and creating incentives for a secondary materials market (link to measure 3 on market of secondary raw materials). That would be the way to go rather than a direct tax or virgin fees tax, which would not sell politically.

Taxing raw material use is considering to conflict with regional economies depending on the raw materials sector. Complex global value chains and a generic lack of acceptance of taxing further complicate this measure.

3.5.3 Measure 3 – Fostering markets for sustainable products and secondary raw materials

Measure 3 is perceived the most relevant of all measures. It was mentioned by three interviewees among their top three and considered by another one as among the ones with the most potential.

Interviewees from four regions consider that there is interest in creating a market for secondary raw materials, as it is seen as a potential win-win arrangement for environment and business (LAC, AP, and Africa), which is more politically feasible than direct taxes on virgin materials (USA). However, they recognise different challenges for doing so (see below). The fifth interviewee (MENA) considers it as having potential, but not very relevant in the short term, as governments in the region lack incentives for becoming active in this area.

Further similarities among the regions deal with the identified challenges for establishing a market for secondary raw materials. The most important ones have been:

- Relatively high price of secondary raw materials (MENA) together with the price of petrol and the fluctuation in the price of virgin materials (LAC), which make it difficult for a market to be established
- Lack of awareness and of political will among decision makers, as well as a lack of capacities and budget in municipalities in charge of waste management to put effective policies in place and guarantee their enforcement (MENA and Africa)
- Poor back-end system of collection and recovery related to the existing infrastructure and the technology for transforming waste into secondary raw materials. There is also lacking investment in this infrastructure and in innovation (innovation is already occurring in LAC)

in order to reduce the production costs of secondary raw materials (LAC and USA). Moreover, there is a lack of market pull that would help matching pricing and product quality of secondary materials (USA).

- Lack of awareness among consumers (e.g. that what is being thrown away still has a value), but also lack of user-friendly collection systems that could encourage also people who are less environmentally aware to participate in recycling (LAC and USA).

While various regions face similar challenges, main differences concern possible ways for dealing with these challenges: In Africa, fostering the market for secondary raw materials first of all requires a clear legal and institutional framework and the involvement of the private sector. In this context, demonstration projects are necessary which show the benefits and encourage companies to adopt more circular practices, e.g. through government programmes that encourage circular economy. Finally, more awareness raising activities are needed.

In LAC, possible instruments to increase the demand for sustainable products and secondary raw materials could be for instance eco-labelling and putting adequate fiscal policies in place (link to measure 2 on raising the price of primary resources). Furthermore, incentivising innovation and the adoption of technologies, e.g. through investment, would also be a suitable approach.

For AP, developing more guidelines for creating and showing the benefits of resource cycles can go a long way in supporting a transition to and establishment of a secondary raw materials market. This would be the case, for instance, for water reuse in industrial sectors, which is not happening in most parts of the region, partially because of the lack of guidelines on how a water cycle can be established between different sectors.

In the USA, it would be most important to create incentives for increasing secondary material content in products, to create infrastructure to optimise technology investment, for instance in the separation process, in order to enable more optimised recovery systems for secondary materials. Such incentives need to be created at state and local government level first, for instance through pilot projects aimed at experimenting and developing approaches that can be scaled up. That would most likely have to start in states or municipalities that already have a good infrastructure system and policy system of recycling, which allow to test such measures. It would have to start with pilot project, but it is also necessary to scale it up at a state level both in terms of policy enabling and required investments mechanisms.

In MENA, the interviewee proposes that a reduction of the price of sustainable products and secondary raw materials could be achieved through research and development to reduce the cost of these products.

Fostering secondary raw material markets appears as the most relevant of all measures and is seen as a clear win-win approach use. Increasing the demand for secondary materials is key, but lacking capacities and technologies for proper waste management are challenging this.

3.5.4 Measure 4 – Designing products and business models for material efficiency and long service life

This measure was named among the top three by two interviewees and among the top four by one interviewee. Thus, it is the second most relevant measure.

The measure is considered particularly relevant in three interviewed regions (Africa, AP and LAC), whereas interviewees from another two regions did not consider this measure very relevant in the short term (MENA and the USA). In Africa, where leap-frogging can already be observed in the rapid adoption of mobile phone networks, it is possible that eco-innovation in production can be adopted. Similarly, in LAC eco-design is seen as a "low hanging fruit", even though it is still at a very early stage. In Asia the potential for the creation of jobs deriving from new, more circular business models is seen as having a high potential for raising the acceptance of such a measure in terms of policy.

In MENA the current low relevance relates to the relatively high amounts of technology, training and budget required to advance material efficiency and longer service life in products. This would render these products relatively more expensive and hence would contrast with the tendency of costumers to prefer cheaper products. In the US concretely, neither product life extension nor material efficiency are currently relevant in the interviewee's view.

However, in spite of the similarly perceived (lacking) relevance of designing products and business models for material efficiency and long service life, the interviewees pointed out differing potentials, challenges and approaches to deal with them. In Africa, while manufacturing is not very widespread, there is an increasing tendency towards more material efficient design due to the potential to reduce costs from (expensive) material input. However, people in the region tend to go a lot with trends, which often means that they aspire to always have the newest, particularly regarding electronic devices. Therefore, a longer service life would not be the main focus of this measure, but rather increasing material efficiency.

In LAC, the challenges mostly relate to a prevailing culture of consumerism characterised by aspiring to have increasingly more of more things, at increasingly lower prices. Moreover, the necessary technology for tapping the potential offered by industrial symbiosis and other circular business models is missing, for instance regarding organic solid waste which accounts for about half of the total waste produced in the region. In order to deal with this challenge, the interviewee considered it most important to raise awareness among consumers and producers about the benefits of eco-innovation. For consumers, this can be achieved for instance through environmental education activities and by making sustainable products desirable and aspirational. Regarding producers, it is important to diffuse the principles of eco-innovation and its advantages in order to increase their willingness to adopt new business models and make them more popular among companies. Furthermore, this could be strengthened through the developing financing and fiscal schemes for private companies to adopt eco-innovation, without having to carry the whole financial burden and risk. Such schemes could equally serve to incentivise repair and reuse among the population. For instance, there are already examples of repair-cafés in Chile and such initiatives could be further supported by government through financial support or tax benefits. Finally, the interviewee considered that planned obsolescence needs to be more strongly regulated by governments in the region.

In the AP region job creation is a top priority as economic growth in the region has not brought an increase in employment (jobless growth). Moreover, a large portion of the population is young and will require employment. Circular economy is also dominated by a very large informal sector, for instance in the recycling industry. Therefore, a top priority would be to formalise already existing business models among informal waste pickers in a socially inclusive and economically viable way so as to improve their efficiency and the working conditions. This also offers the potential of fostering cooperation between different ministries that do not interact that much otherwise (for instance economy and environment ministries).

In the MENA region, the issue is relevant, but due to the relatively higher price of more efficient products, these are perceived as too costly and people tend to go for cheaper products due to

budget constraints. For instance with LED lightbulbs, this has started to change as the investment cost is still low. Therefore, even if LED bulbs are still much more expensive than conventional ones, their energy saving potential and longer service life have made them generally more attractive. In contrast, an investment in more expensive appliances such as refrigerators is often unaffordable, regardless of the long term cost-effectiveness. Hence, raising awareness about the long-term cost-effectiveness of products that are more efficient or have longer service life is important. Nonetheless, subsidies can also represent a challenge. For instance, solar heaters were very expensive and electricity very cheap so people would not use a solar heater, due to the low energy prices subsidising the use of electrically run water heaters. After subsidies in electricity had been reduced by governments (not specified), using solar heaters has become more cost effective.

In North America, according to the interviewee, life extension of products faces a fundamental challenge at a global level. This is related to its business implications, as the value proposition of product life extension is still not well understood. The primary product manufacturers view product design more in terms of short to mid-term product functionality and not of product lifetime. Thus, it is required to increase the visibility of design for life extension activities or for integration of recycled content at a global scale. In this context, it is important to improve the understanding of the business based, environmental or social outcomes that are associated with it. Regarding material efficiency and circular economy, more needs to be done in terms of communicating the value add proposition from a business and a societal perspective in order to increase the receptivity for those actions. Thus, it is necessary to raise awareness based on a quantitative analysis on economic and other benefits of resource efficient or circular business models. It is necessary to do a focused outreach based on all those opportunities, identified through robust data.

Designing products and business models for material efficiency and a circular economy is seen as having great potential, but rather in the longer run. Relevant challenges encompass modern consumerist cultures as well as lower prices for virgin than secondary materials and products.

3.5.5 Measure 5 – Making re-use and repair of products easier and more attractive

This measure is considered relevant in four regions (Africa, AP, LAC and MENA). However, only two of the interviewees ranked this measure among the top three. Relevance in the USA is rather low, as repair is organised around “cottage industries” and the interviewee currently does not see a potential for upscaling.

For the Africa, AP, LAC and MENA regions, the interviewees pointed out that there has been traditionally a culture of repairing and using things as long as possible that still prevails, but it is slowly disappearing. The interviewees for these regions agree that it is important to take actions to keep the culture of repair and reuse, particularly in light of the current trend of periodically buying new things. A further similarity in the replies from interviewees from the AP, LAC and MENA regions is the perception that incentivising reuse and repair could be beneficial for countries due to the job generation potential of reuse and repair. Thus, they propose that focusing on the job creation potential would make this measure more appealing. Nevertheless, while they see similar opportunities in keeping repair and re-use from disappearing, the interviewees point out different challenges to and potential ways for reverting this trend in their respective regions.

In LAC, the main problem identified is the increasing lack of availability of spare parts for repair. Dealing with this issue would involve establishing regulations and incentives for spare parts, repair shops and tackling planned obsolescence (link to measure 4) as well as strengthening EPR

by making it an obligation for companies to make spare parts available. Another mentioned example was incentivising remanufacture and reuse by giving fiscal incentives like tax exemptions for repair shops, a measure that has already been successfully implemented in some countries in the region for companies that adopt clean technologies. Moreover, labelling could be an effective way of promoting reparability and longer service life in products, for instance by defining criteria that rule out planned obsolescence for products that become certified. A final aspect that could potentially meet acceptance in the region would be changing business models to sell services rather than services (function based approach – link to measure 4). However, the enabling conditions for such business models to work are still missing in order for these kinds of offers to be competitive.

In AP the main challenge for repair and reuse, according to the interviewee, is related to price and accessibility of repair services. Due to expansion of global value chains and opening up of economies, the number of devices has grown, diversity of products has expanded and prices have gone down. At the same time, the local repair culture has been replaced by centralised service centres, which for many products are still very hard to reach for customers. As the transportation costs to service centres are commonly born by consumers, people give up on these products because it becomes too expensive to repair and rather buy new products. According to the interviewee, governments can play a key role in dealing with these challenges. For instance, they can ensure that such service centres exist and that collection centres are available, at least for all the major electronic goods. Moreover, governments can support businesses or collection centres in efforts to reduce transportation costs towards consumers to get their products to these centres, for instance by making it easier to send devices by courier. However, a central question here would be who has to pay for this. Therefore, the interviewee points to the need for putting more EPRs in place and enforce them in order to ensure that products that come into the market have accessible service centres or comply with certain kinds of standardisation. That would allow other stakeholders besides service centres to actually do the repairing for minor issues. Lastly, as the shared economy and online platforms are gaining popularity as a way to organise an already common practice of buying second hand or borrowing informally. Governments can help facilitate such platforms, which could work even at a very local level.

In the MENA region, a proposed way to deal with the effects of an increasing availability of cheap, low quality imported products (mainly from China) would be to set up quality controls on imported goods. However, the interviewee recognised that, while some regions have already implemented such measures (regions not specified), putting in place good quality standards and properly enforcing them through customs can be very challenging as well. Therefore, another potential approach suggested would be to issue quality assurance certificates for service centres in order to increase trust in them. Additional to this, it is crucial for governments to invest in training of a repair workforce that to promote high quality repairing that is perceived as economically feasible in comparison to buying new products.

In Africa, the main challenge, particularly regarding electronic devices, is related to trends. To this respect, the interviewee argued that technological products are becoming quickly outdated and the general trend is to buy newer devices, not to reuse or repair them. This is a particularly big challenge in Africa, as the 60% of the population in Africa is youth who tend to go with trends. Consequently, there is a perceived need to have the newest, most up-to-date devices which is what the youth generally wants and is widely considered as the basis for development. It therefore very hard, if not impossible, to halt this trend-dependency. Therefore, the most important step, according to the interviewee, is to take measures to raise awareness about the problems related to such consumption patterns and to encourage a proper end-of-life disposal.

In the USA, there is no prevailing culture of repair anymore. Therefore, the interviewee links this issue closely to product design and the business side considerations associated with it (this links

to measure 4 above). Similar to AP, the interviewee points out to this issue as being highly influenced by the globalisation of value chains. In this context, the issue of repair is a particularly acute problem because there is a certain tension among businesses regarding the effects that designing for reparability can have on the first use of a product. Thus, some businesses believe that it is best to design for maximising the functionality of a product in its first use and that enabling repair can potentially reduce this functionality. Hence, there needs to be a deep analysis of what products best lend themselves for repair circumstance for an original manufacturer as well as for the first user and second user. As a first step for the USA, it would be important to assess the economic and climate value-added of repair for different products in a rigorous way, using both as a basis to decide whether it makes sense to increase reparability. Furthermore, systems of standardisation and certification of repair are required in order to actually achieve more repairing and managing to upscale it in a way that it becomes a viable component in the value chain for manufacture, first users and secondary users.

Re-use and repair are relevant in low to middle-income countries, in which repair is also more deeply enshrined in culture. This measure has promising potential for job creation, but product and business model design often counteract re-use and repair.

3.5.6 Measure 6 – Reducing plastic waste

All interviewees consider this measure relevant. This measure was named in two cases as one of the top three. However, the interviewee for the USA points out to the need for differentiating between plastic production and waste. Following that logic, the USA has mostly a problem of plastic production, which is effectively collected but mostly put in landfills or incinerated. Other countries like those in the regions of AP, LAC, MENA and Africa rather have a problem with plastic waste and the environmental impacts associated with its "leakage" to the environment. According to the interviewees for these regions, the growing political relevance of dealing with plastics is closely related to an increasing awareness about these impacts.

In Africa, AP, LAC and MENA there are already various examples of ongoing initiatives and existing legislation aimed at reducing plastic waste in different countries. These focus either on banning (mostly of plastic carrier bags or single-use plastics), or on creating incentives to avoid their use (e.g. putting a price on plastic bags or encouraging supermarkets to promote reusable bags). Latter actions have for instance boosted the use of more sustainable alternatives to plastic bags with various degrees of success. For instance in Africa, it has been reported that the policies have caused many cities to return to using palm tree bags, which were common before the boom of plastic bags and have remained in use in rural areas. Moreover, in LAC new bioplastics made out of materials available in the region have started to develop as a consequence of such policies.

The interviewees for Africa, LAC and MENA regions see policy development in their regions as going in a very positive direction, e.g. regulations prohibiting single-use plastics or carrier bags and creating economic incentives as well as creating price incentives to reduce the use of bags.

The AP interviewee points out at the limitations of acting through regulations alone and that solving the issues of plastic pollution requires a gradual change. For instance, recycling systems need to be re-thought to make waste sorting easier so that plastic reaches the places for recycling. It is not only about avoiding single-use plastics, but also about what happens to other plastics, how easy it is to sort it and ensure that recyclable plastics do not end up on landfills, but actually get recycled. Hence, the entire waste management systems need to be re-invented, which is the biggest challenge.

For the USA, the interviewee agrees with the fact that a sole focus on single-use plastics is misguided, because it doesn't really look at system solutions and detracts from the kind of investment and policies that are necessary to begin shifting towards a circular strategy. Accordingly, the short term problems in the USA are combined collection and lack of education. Therefore, a circular strategy should start with an optimisation of separation and separation technology, also to increase the yield of recyclable plastics that are recovered. First interventions, which can already be implemented would include consumer education, investment in better sorting technologies and optical technologies to have better separation, reducing contamination in the collection side. As a next step, it is possible to go more upstream by incentivising to use as little plastic as possible in the first place, particularly single-use plastics, packaging and over-packaging, as well as looking at ways to eliminate the incentives for them. Moreover, in the longer term it would be possible to go on creating business models around maximising recyclability of plastics which deals with reformulating polymers to increase recyclability. Thus, it is crucial to apply systemic thinking that includes also a mid and long-term perspective and avoid rushing to trying to solve only the problems of today. This is a particular challenge in the USA, where the focus of investment has and is still strongly put on building up waste incineration capacities, which inhibits circular strategies.

On the political level, both in the USA and globally, the challenge is that there is no specific agenda regarding investment priorities. For instance, whether it makes more sense to invest in incentives or directly invest in optimising separation and collection of recyclable materials on the back end. In general, it is necessary to increase the collection and ensure the decrease of contamination in collection systems in order to increase the recycling yields. According to the interviewee, this can be achieved right now in any municipality of the USA. However, this requires at least a state base investing in such systems in order to work, which is more likely than the federal government doing so. But in order to justify the investment in such systems, it is necessary to improve knowledge regarding the expected economic, macro-economic (e.g. job creation) and environmental value that they could generate.

Reducing plastic waste is considered relevant in all regions, but existing collection and sorting systems pose a key challenge and lead to plastic waste being littered.

3.5.7 Measure 7 – Making the built environment more material efficient

This measure was considered relevant by the interviewees of LAC and AP due to the high rate of urban population in these regions. Both also ranked this measure among their top three. As for Africa and MENA, both interviewees consider it important to increase material efficiency in the construction sector due to its cost-saving potential, but did not elaborate on the political relevance of the measure, challenges or ways of dealing with them.

The built environment in AP and LAC is a very relevant issue. For instance, 80% of LAC population already lives in cities and urbanisation trends together with construction demand and expansion in AP are projected to be very high. Consequently, regulations have already been passed in both regions. These have been for instance aimed at increasing construction and demolition waste (CDW) recycling, like in India where some cities have defined minimum recycling quotas of CDW; or at increasing the use of recycled materials like in Colombia where a law has been passed which defines a certain quota of recycled materials for new buildings, which shall increase with the years.

According to the interviewee for AP, the existing building stock is very inefficient and there is very little recycling of construction waste in the region. However, despite first examples of regulation to increase CDW recycling in AP, the key challenge is their enforcement, which is often

connected to a lack of sufficient personnel to monitor and review these kinds of things. Hence, the interviewee believes that regulations with strict enforcement at city level could become a real game changer in terms of how resources are used in cities. Thus, it is necessary to work with city administrations, mayors and local governments in order to enforce rules at a local level. Further challenges to the enforcement of policies are connected to administrative difficulties such as having to deal with several types of permits. For instance, building and environmental permits are issued by different departments. Therefore, it is also relevant to harmonise permit systems to include all issues into one permit system, including management of construction waste, how material is used in new constructions, etc.

For LAC, the most relevant aspects regarding sustainable buildings are currently water and energy, but material efficiency is becoming increasingly discussed as an important challenge. Another challenge mentioned is the widespread perception that sustainable buildings are more expensive than conventional ones. Some independent initiatives already exist aimed at encouraging more sustainable buildings, for instance creating manuals and online tutorials on how to do it. These have been also partially supported by public entities, e.g. in Argentina. Such support could be increased and also expanded to include aspects of material efficiency. A positive signal in this direction is that green building councils have been already established in several countries in the region.

Furthermore, particularly commercial developers are lacking incentives to build more sustainably/efficiently, as the economic the benefits of energy and water savings are not relevant to them after they sell the properties. Thus, the interviewee considers that regulation is needed in order to force commercial developers to build more sustainably/efficiently.

Making the built environment more sustainable is a relevant, yet challenging issue particularly in highly urbanised regions, experiencing or expecting population growth. Legislation and technology are often not efficient enough to build more circular.

3.5.8 Measure 8 – Creating a sustainable food system

This measure is considered relevant in four of the regions (AP, LAC, MENA and the USA), particularly regarding food waste. Two interviewees considered it among their top three. The discussion about this measure was mainly divided between the topics of food waste and plant based diets.

In AP and LAC food waste is an increasing problem which is strongly related to increasing income and a growing middle class, as it is the global tendency. In the MENA region and AP, there is also a cultural component linked to food waste. For instance in AP, it is culturally encouraged to have big feasts with lots of variety and quantity of food where guest should not be able to finish the food served. In the MENA region, the interviewee considers that people are in general very generous and make more than enough food and also bring more food than needed e.g. to celebrations and do not consume all. According to the interviewee for MENA, there is a lack of awareness about using only the amount of food that is needed, while the AP interviewee considers that perceptions on food can only be changed with behavioural interventions.

This applies also to meat consumption and plant based diets as well. Increasing meat consumption is also associated with higher income, but in AP, LAC and USA there is a growing trend of shifting towards more plant-based diets due to health and environmental concerns. However, this remains a niche in all three regions that needs to be addressed. In LAC and AP, the interviewees appeal to the need of making the shift towards plant based diets more aspirational, as meat consumption tends to be perceived as a status symbol.

The USA proposes a similar approach, arguing that the support of religious or popular figures in the outreach in favour of plant-based diets could help make them more aspirational and culturally acceptable. Latter aspect is particularly relevant in the multicultural setting of the USA, where meat consumption is also tied with cultural and religious tradition. Thus, creating regulations aimed at meat consumption can face opposition from the public but also from the meat and dairy industry, which have a very strong lobbying power.

Similarly in LAC, while awareness about the health and environmental benefits of a plant-based diet is increasing, it still faces various challenges, particularly regarding the cultural importance that meat has in particular areas, most notoriously the so-called "southern cone" sub-region (Argentina, southern Brazil, Chile, Paraguay and Uruguay). There, meat consumption plays a very important role in the local culture, which makes political measures aimed at limiting meat consumption a very sensitive matter and are met with general rejection. Thus, measures aimed at increasing awareness to reduce (but not completely phase out) meat consumption are the ones with more likelihood of success at this moment. Likewise, the interviewee for the USA also considers it key to tailor the message of a plant-based diet so that it gets to the consumers without doing a broad attack on the meat and dairy industries. That means making clear that it is neither an opposition to those who choose to eat meat nor necessarily promoting giving up meat completely, but rather to integrate the plant-based diet into diets for all health and climate protection benefits associated with it.

In MENA, the focus of the measure should be on the efficient use of resources in food production, particularly regarding water e.g. through modern irrigation systems or by introducing more efficient crops that consume less water and resist drought. The selection of more efficient cropping patterns or the recycling of agricultural waste could be relevant approaches. However, still a lot of work needs to be done, also regarding food waste. For example, there are some initiatives to conserve and redistribute food, such as food banks, as well as encouraging people to pack food left-overs to use them afterwards or give it to other people. In this context, the interviewee suggest that it would be important to further develop and incentivise mechanisms to conserve food or to use food left-overs it in other ways, for instance through drying. Moreover, reducing subsidies can help to reduce food waste, as it has happened in Egypt. There, the reduction and targeting of subsidies on bread has successfully contributed to a reduction in bread consumption. This has been politically difficult, but since the reduction was targeted in a way that it does not hit the lowest-income population, the results have been positive regarding the burden distribution, usually a key difficulty met when reducing subsidies.

In the USA, the focus of the measure would have to be on food loss, which mostly occurs post-purchase. There are various opportunities for instance regarding consuming education, but also in terms of data and digital mechanism to shift waste from being thrown away to being productive in value. For example, there is experimentation with online platforms for making expired food available for collection in various places around the country. These efforts are being led by civil society groups fighting hunger and organising logistics of picking up and delivering saved food in various places. However this is happening at a localised level, which would need to be scaled up. Furthermore, more rigorous, potentially more complicated but more valuable approaches would involve creating the data infrastructure to identify how to minimise food production in a way that meets demand. This implies anything from manufacture to retail and how to create the required data input, even within the same food manufacture facility. Thus, creating that data and pulling it into a dashboard to identify opportunities for reducing food loss. The potential of such approaches is big, but they could be optimised further in the USA.

Reducing food waste is a central focus of making food systems more sustainable in most regions. Cultural aspects make the uptake of plant-based diets difficult.

3.5.9 Potential blind spots and missing measures

In terms of additional measures, interviewees for AP and LAC see the need for lifestyle changes, for which to achieve they call for nudges and awareness raising to facilitate behavioural changes. Key to this is to have role models who show these changes can be done and that inspire others to aspire making these changes (portraying changes as something positive and aspirational). The interviewee for the USA pointed out that measures supporting behavioural changes should feature more prominently in the current measures or as a stand-alone, additional measure.

The interviewee for LAC recommended to emphasise more the polluter pays principle and the internalisation of environmental cost (which are already related to measure 2 and measure 3). Additionally, the interviewee suggested also introducing a measure that improves financing for sustainable innovation and technology transfer (adoption), because this constitutes a largely untapped potential in this region.

With regards to AP, the interviewee would rather consider increasing resource productivity in manufacturing as a dedicated measure in its own right and not as part of wider measure 4.

The interviewee for Africa viewed all measures as being too focused on urbanised, highly educated areas. For rural areas, where education levels are often lower, the interviewee proposed that, if the measures are to be implemented, a component of dialogue or consultation with affected communities needs to be included. In Africa, currently on average only about 40% of the population is living in cities, although this is estimated to rise to 50% in the near future.

The five interviews conducted with resource conservation experts from different world regions revealed relevant contextual conditions, which could – or do – potentially affect, if and how resource conservation policy could be implemented in the different regions. In addition to the findings shown above per resource conservation measure, the following Chapter 0 provides a summary of key context conditions per region potentially affecting climate protection and resource conservation.

3.6 Summary of key findings on regional relevance and context conditions potentially affecting climate protection and resource conservation

In this section, we first highlight those climate protection and resource conservation measures, which the regional interviewees considered most relevant for and fitting to their respective regions (Chapter 3.6.1). Secondly, we provide a summary of key context conditions per region that potentially affect if and how climate protection and resource conservation could be implemented (Chapter 3.6.2).

3.6.1 Climate and resource conservation measures considered most relevant per region

Overall, the interview findings show that the entire set of measures identified for climate protection and resource conservation appears relevant on a global level. On a regional level, depending on regional context conditions, certain measures were considered favourable over others, thus providing a picture of regionally differing entry points for climate protection and resource conservation measures. Therefore, it is important for the interpretation of the results (see Chapter 4) to take a look at the key findings on relevant context conditions, which could potentially affect if and how both climate protection and resource conservation measures can be implemented (see Chapter 3.6.2).

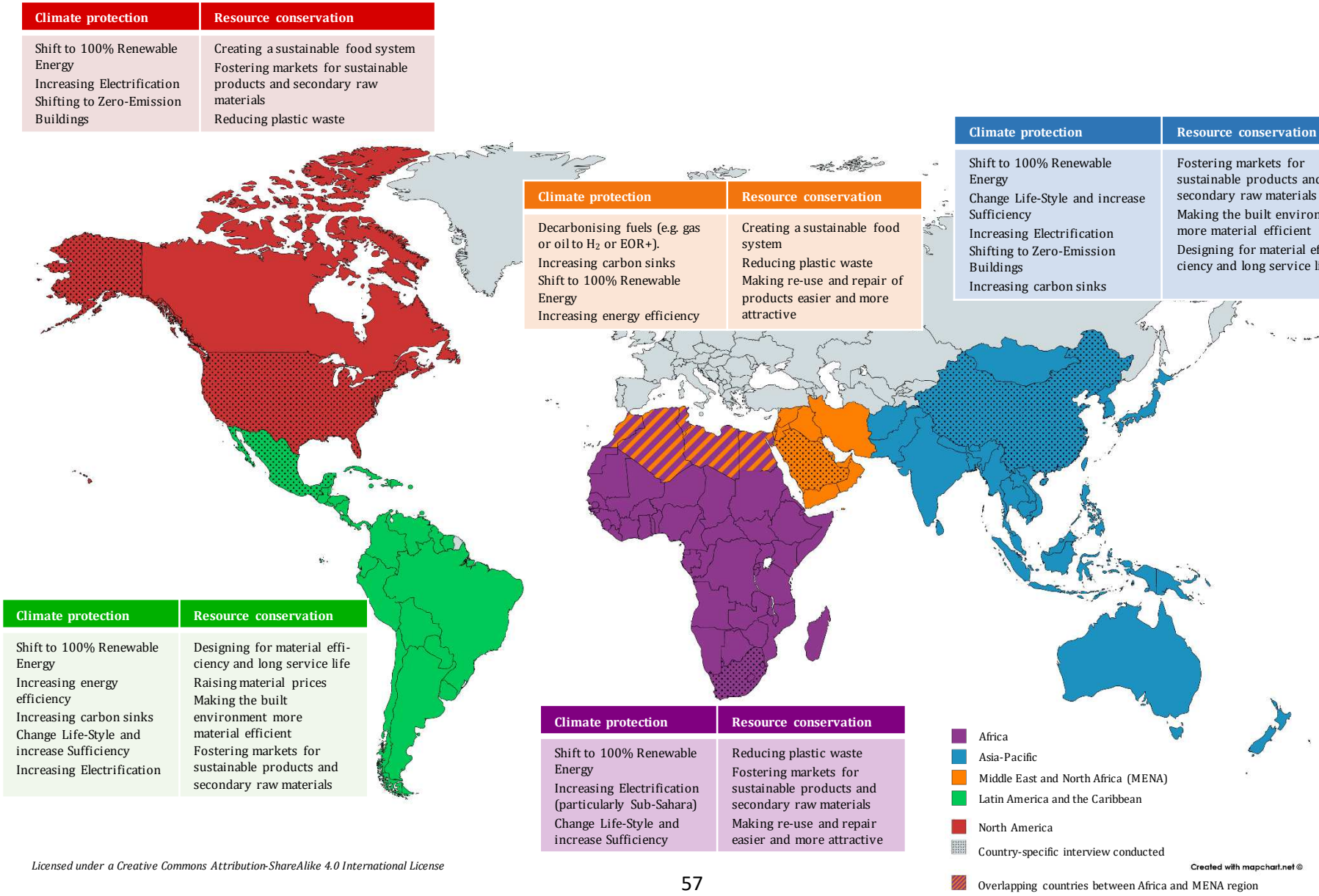
Figure 1 on the following page shows this picture by summarising the most relevant climate protection and resource conservation measures according to regional interviews. In order to assess the relative relevance, the interviewees were asked to name their top three measures. Answers to this question varied considerably, as some interviewees provided more than three top measures, did not specify order of relevance or did not provide a selection of top measures at all. Thus, this assessment relied also an evaluation of each measure's relevance expressed by the interviewees throughout the questionnaire.

Climate protection measures

Overall, in four out of the five regions covered in interviews the measure '*shifting to 100% renewable energy*' emerged as a top measure – only in the MENA region other measures were considered more urgent or relevant, in particular decarbonising fossils fuels (e.g. shifting from gas or oil to hydrogen (H_2) or towards CO_2-enhanced oil recovery (EOR+) and the measure '*increasing natural carbon sinks*'. The measure 'i*ncreasing electrification*' featured as a relevant measure in Africa, AP, LAC and the USA, while the measure '*increasing natural carbon sinks*' is considered relevant in AP, LAC and MENA. Interestingly, the measure '*changing lifestyles and sufficiency*' ranked among most relevant measures in Africa, AP and LAC, but was not listed for MENA nor the USA. The measure '*shifting to zero-emission buildings*' was identified as a relevant measure in AP and the USA. No interviewee considered the measure '*reducing fertilizer use and liquid manure input on fields*' among those most relevant.

As an additional measure, which was not part of the set of six climate protection measures identified, increasing energy efficiency was listed as a relevant measure for LAC and MENA.

Figure 1: Overview of most relevant climate protection and resource conservation measures according to regional interviews



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Resource conservation measures

Across all eight resource conservation measures, the measure '*fostering markets for sustainable products and secondary raw materials*' ranked among the most relevant measures in four out of the five regions covered: Africa, AP, LAC and the USA. The measure '*reducing plastic waste*' featured among the most relevant measures in Africa, MENA and the USA. The following resource conservation measures each emerged among the most relevant measures in two of the five regions covered:

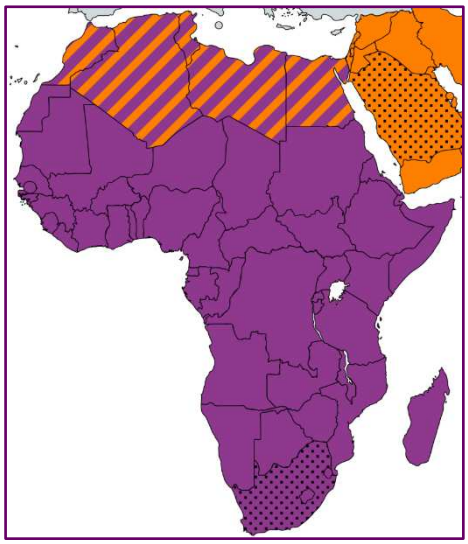
- '*Making re-use and repair of products easier and more attractive'*, for Africa and MENA
- '*Making the built environment more material efficient'*, for AP and LAC
- '*Designing for material efficiency and long service life'*, for AP and LAC
- '*Creating a sustainable food system'*, for MENA and the USA.

The measure '*raising prices of virgin materials*' only featured among the most relevant measures in LAC. No interviewee considered the measure '*setting a global per-capita resource use budgets*' among those most relevant.

We will now turn to relevant context conditions, which could potentially affect if and how both climate protection and resource conservation measures can be implemented.

3.6.2 Relevant context conditions potentially affecting climate protecting and resource conservation in different regions

Relevant context conditions mentioned for Africa and selected sub-regions and countries



Climate protection: Compared to other regions, Africa has a lower energy consumption, but energy intensity of many of its national economies is higher than in other regions. Furthermore, there is a strong economic and cultural attachment to coal as well as a historical path dependency in Africa. The coal sector is facing challenges because China is offering inexpensive coal technologies to African countries, which intensify the competition that (the use of) renewable energy sources faces.

Furthermore, new fossil fuel discoveries and a need for higher efficiency in processing fossil fuels are key issues complicating climate protection in Africa. Finally, there is a big charcoal issue in Sub-Saharan Africa, especially for cooking, which is emission intensive and leads to health issues.

Resource conservation: Many national economies in Africa are highly dependent on raw material extraction. Overall, the population in Africa on average is living in rural regions (only 40% of population on average is living in cities) and is very young (around 60% of population are youth). Particularly the young are very responsive to trends and interested in getting the newest devices, particularly cell phones and smartphones – in Africa, leap frogging has been observed in

the development of mobile phone networks instead of building landline systems in the first place. Owning the right devices is often perceived as something necessary, not least for economic development. Therefore, awareness raising is considered crucial.

Material efficiency is gaining relevance due to cost-reducing potential. A repair and re-use culture still exists in the region and also is economically relevant in terms of providing jobs in the region. However, it is decreasing in importance.

Regarding waste management, there is a lack of regulation and policy and terms such as waste and resources are not well defined in existing policy. As uncontrolled incineration and illegal dumping of waste in rivers is a major problem in the region, proper end-of-life disposal and waste management come into focus. This also concerns plastics (particularly single-use plastic products, such as carrier bags), which are widely recognised a problem. The need for taking action has been recognised and also partly addressed through policy in certain countries (prohibition and incentives for alternative materials, e.g. palm tree fibres).

North Africa

Climate protection: North Africa has a high potential for energy efficiency as well as for solar power, but this is not fully used. In Morocco, the government is engaging to extend solar power. However, most projects dealing with renewable energy supply and electrification need upgraded infrastructure and require high upfront investment costs, but the capacity to invest is limited. Furthermore, financial support is insufficient and not always easy to access in the region. Also, there is a lack of knowledge and capacity of local and/or national governments to create enabling frameworks.

Currently, diets are very fish and meat intensive, which is difficult to change due to cultural attachment and availability of fish and meat in the region. General, lifestyle-change and sufficiency are not really discussed in politics nor by the public.

Southern Africa

Climate protection: Southern African countries show high unemployment and strong unions. Public transportation is largely perceived not safe to use. There is significant urbanization taking place, which increases the need for new buildings. The building industry is small, but cement-based and as a result highly emitting.

Diets are traditionally very meat-intensive and changing diets is a sensitive topic. There are only small pockets of environmentally conscious people, which is by no means a mainstream.

Emissions from land-use and deforestation in South Africa are not so high compared to other parts of Southern Africa (e.g. Congo).

Relevant context conditions mentioned for Asia-Pacific and selected countries

Climate protection: Some countries in AP experience shortfalls in electricity supply. Thus, increasing electrification will put even more pressure on the grid and hence could be complicated. In this context, decentralised electricity generation and supply are considered the way forward in the region, with demand for electricity from heating and cooling becoming more important.

Slash and burn practices due to intensive agriculture pose a big problem for forest conservation and thus reduce potential carbon sinks.

Using renewable energy sources can bring significant health improvements through reducing air pollution, particularly in East Asia. However, land-use conflicts already exist in AP regarding solar energy vs. food production, especially in South-East Asia and India.

Resource conservation: The region is highly urbanised with a very fast urbanisation rate, driving demand for new buildings and infrastructure. The existing building stock is rarely used as source of secondary materials. Extractive industries are a very important sector in most countries of the region and the sector's political influence is high. Not least therefore, the region is very sensitive to direct price increases (e.g. via taxes). Furthermore, the region generally witnesses low administrative capacities for designing, implementing and enforcing taxation measures (with China being an exemption, which has already implemented environmental taxation systems) – including adequate distribution of tax revenues.

Many business models that help to conserve resources already exist, but often as part of the informal economy, e.g. in recycling. Therefore, there is great potential for fostering such business models by formalising these models in the region and improving working conditions.

More attention should be paid to sustainable sources for metals and mining. Urban mining – meaning using old electronics – could help in this regard. A second life or an extended life for products needs to be created, and there should be a higher materials efficiency. However, there is a lack of awareness of (also economic) benefits of using secondary materials as well as a lack of guidelines that encourage businesses to become circular. Also in this regard, green Public procurement has to be strengthened-

In AP, a repair and reuse culture still exists, but it is decreasing and becoming more centralised with an associated loss of local repair options.

Plastic is a key issue and the cause of a lot of pollution in the region, particularly single-use plastic products such as carrier bags. While the need for taking action has long been recognised and is addressed through policy in certain countries, waste collection and recycling systems are mostly not very well established or organised.

Historically, the diet in this region has not been based on high animal-protein-intake. However, its consumption is increasing due to due to growing middle class – eating meat has become an aspiration and lifestyle issue with increasing affluence. Therefore, promoting positive examples for lifestyle change, e.g. by making sustainable lifestyles (like sustainable diets) an aspiration could have a potentially high impact. Furthermore, a culture of big feasts, where more food that what could be consumed is served, is widespread throughout the region, often leading to food waste generation.

China

Climate protection: Given its political and economic system, China is good at implementing centralised projects, such as to produce electricity from wind and solar power. These are large-scale, concentrated projects, with a lot of financial and technical expertise needed, but with less stakeholders involved.

The building sector is decentralised, hence shifting to zero emission buildings is complicated by unclear and varying ownership and responsibility for management and renovation.

In China, people strongly relate to (remediation of) air and water pollution, but hardly to climate change and (any need for) sufficiency or lifestyle changes.

Relevant context conditions mentioned for Latin America and the Caribbean and selected countries

Resource conservation: LAC is a very urbanised region, where some 80% of the population already lives in cities. The cities of the region experience a strong consumerism culture, making awareness raising very important, e.g. by promoting positive examples for lifestyle change and making them aspirational. Eco-labels could further help fostering sustainable consumption. There is already cooperation within the region for developing a LAC Ecolabel.

Civil insecurity, particularly regarding the use of public space, very widespread and influences many aspects of people's lives and choices.

Similar to Africa and AP, extractive industries are a very important sector in the region and the sector's political influence is high. Not least therefore, the region is very sensitive to direct price increases (e.g. via taxes).

(Eco)Innovation is occurring in many fields (relevant for resource conservation, e.g. waste management technologies, e.g. for tire recycling), but financing of innovation, technology and infrastructure is largely lacking.

A repair and reuse culture still exists and provides jobs in the region – as in Africa and AP, its relevance is decreasing.

Plant-based diets are starting to become a trend in some areas of the region. However, meat-based diets prevail in other regions: in the "Southern cone" (Argentina, Chile, Paraguay, Uruguay, and Southern Brazil) there is a very strong cultural relevance of meat, limiting the policy options targeting meat consumption.

Plastic is a key issue and the cause of a lot of pollution in the region, particularly single-use plastic products such as carrier bags. The need for taking action has long been recognised and is addressed through policy in certain countries (e.g. fostering bioplastic use).

Mexico

Climate protection: Mexico does not produce much renewable energy, which is considered a missed economic and social opportunity, not least because energy storage is a large challenge.

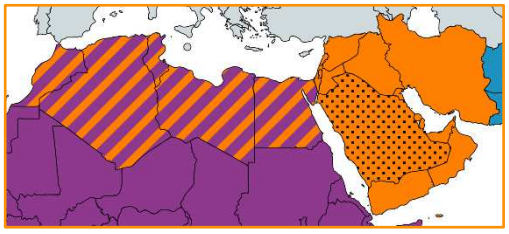
Land use for renewable energy sources has conflict potential, e.g. the discussion on food vs. fuel and how the land is negotiated. There is lot of misinformation, corruption and human rights violations.

Making buildings more energy efficient is complicated for the existing building stock. Retrofitting is possible for private actors. Landlords that own property in popular neighbourhoods maintain the status quo, because the demand for their property is always there. Only policy can make a change here. The landlord/tenant–dilemma also plays a role.

In Mexico, the question on how to make outside spaces safer so that people could engage in more sustainable outdoor activities is relevant. Currently, the only safe spaces are malls, which promote consumption.

At the moment, the focus is on work and safety in the society, instead of on climate change. Diets consists of a lot of vegetarian, but also meat dishes. Traditional food is part of the national identity, which decreases with the younger generation. There is a shift towards plant-based diets in the younger, urban generation.

Relevant context conditions mentioned for MENA



Climate protection: Due to the low-cost, abundant liquid fossil fuel resources in the region, renewable energy production and electrification across sectors will likely occur later than in other parts of the world.

Extreme heat significantly reduces battery life and thus complicates energy storage and electric mobility in the region. Similarly, because of low building heat demand, heat pumps are not a relevant technology in the region. Across the region, there is considerable opportunity to do energy efficiency retrofits for buildings.

Resource conservation: The population in the region is very price sensitive. Therefore, there is a lack of acceptance for taxes or for the reduction of subsidies in contrast to measures that are cost-effective in short run, which enjoy great acceptance. In this context, awareness raising about long-term cost effectiveness is needed.

A repair and reuse culture still exists and is important in the region, but is decreasing – mainly due to concerns about the quality of repair in a rapidly moving technological environment.

Plastic is a key issue in the region, particularly single-use plastic products such as carrier bags. The need for taking action has been recognised and is addressed through policy in certain countries.

Furthermore, bringing more food than necessary (e.g. in celebrations), is widespread throughout the region, often leading to food waste generation.

Relevant context conditions mentioned for North America (USA)

Climate protection: The US economy is very much focused on short-term returns, especially driven by the financial market and corporates. The price of gas is only a quarter of that in Europe. In addition, all sectors deal with low energy costs, as both oil and gas are very cheap. Electricity prices are also a lot lower in the US.

The federal government does not define a binding building standard regarding energy efficiency. The only standards in place are not legally binding and show very low ambition. Even new constructions currently still have very low standards. In general, households have bigger square footage both in private and office buildings than in the EU. This erodes efficiency. Buildings also have a relatively shorter life span. People often cannot pay their energy bill, even with low energy costs. As a result, renovation would be difficult. Renters do not pay energy separately, so there is no incentive for them to save energy. Efficiency improvements have lower monetary benefits than in the EU due to low energy costs.

People eat a lot of meat, which also means that a lot of corn and soy is grown to feed to cattle.

People need to accept that climate change is happening and share the burden of climate protection action. Currently, they all feel like they are the victims of climate policy. With regard to lifestyle change and sufficiency, people are starting to feel bad. However, they are not willing to make substantial changes. They know that they should do so, but are caught up in habits.

Carbon sinks have a huge potential as there is a lot of land available (especially if meat consumption were lower). However, the increase in wildfires reduces the forests' ability to store GHG, which poses a threat to GHG reduction. Although there is large potential for carbon storage through natural sinks, political and social debates circle around the idea that god gave the land to the people and that they should use it. In addition, nature conservation rangers and farmers collide on the topic of carbon sinks.

Resource conservation: A well-functioning federal system enables scaling up innovation (technological, governance, management, social), which have proven effective on the local or municipal level (pilot or demonstration projects) to state and then federal level. But without such a test of innovation a local level, achieving changes at federal level is difficult.

Taxes are a politically sensitive matter. Creating the right positive market incentives is considered more effective, for instance for optimising systems for secondary materials recovery.

Regarding waste management, the USA rather witness a problem with excess of plastic production than with plastic pollution (as in other regions). Incineration and landfilling are predominant waste management strategies.

Repair and re-use are not very relevant and occur at a very small scale, partially due to lacking standardisation and certifications of repair and lack of visibility of climate benefits of repair and re-use. In order to foster re-use and recycling, improvements in back-end system of collection and recovery are needed as well as investments in technology and consumer education.

Material efficiency and long service life of products are not a priority. On the one hand, the value add proposition of long service life is not entirely accepted among producers who tend to prefer design for maximum product functionality in its first use life. On the other hand, receptivity for material efficiency among business is not very high, partially because its value-add proposition has not been properly communicated

Meat consumption is culturally very relevant in many ethnic groups and measures aimed at changing it could face difficulties of acceptance. Support of key figures in these communities (celebrities, religious leaders) could help raising awareness and making dietary changes something aspirational.

Food waste a big issue, but ongoing initiatives and digitisation show great potential to reduce it in an economically viable way.

3.7 Key findings – Interactions between climate protection and resources conservation measures

Overall, very few interviewees indicated interactions between climate protection and resource conservation measures. A key reason seems to be a lack of focus on this topic in their professional environments and hence limited expertise on the climate-resource-nexus.

Climate protection interviewees mainly stated that a more efficient use and the recycling of resources also reduces GHG emissions compared to extraction, production, processing and transport of virgin materials and products. Two interviewees mentioned the trade-off between

climate mitigation and resource conservation in terms of renewable energy production and associated increase in (certain) raw materials, for instance increased use of steel and cement for the construction of wind power and rare minerals for solar photovoltaics. In this context, it was argued that under a lifecycle perspective, the climate protection advantages of renewable energy vs. fossil fuels seem to diminish. For example, for solar energy, one needs to take into account the production of PV cells and batteries, as well as how these components are transported, used and disposed of. This also includes the sourcing of materials, such as heavy metals, which also poses a political and environmental challenge. Here, the climate-resource-nexus emerges regarding both an increased additional material demand for renewable energy production as well as potential additional GHG emissions linked to producing and transporting materials and components.

Resource conservation interviewees generally recognised that all measures could have an important impact on reducing GHG emissions. However, the interviewee for Africa pointed out that the region only has a minor contribution to GHG emissions. Hence, climate change adaption was considered more important in the region. For instance regarding buildings, while increasing material efficiency is important, not least due to cost-reduction potential, it is more relevant to make buildings more suited for climate change impacts.

The interviewee for resource conservation from the US supposed that for most people, both globally and in the US, it is not clear that creating a circular economy is a value-add proposition for climate protection. People do not link climate issues with materials, even though materials use across the value chain is responsible for about 50% of GHG emission. This lacking awareness further complicates the scaling-up of resource conservation measures, where climate co-benefits could provide an additional argument in favour of fostering resource conservation.

Overall, people in the US would also hardly see socio-economic benefits of a circular economy. Here, introducing a metric to make co-benefits for people, the economy and climate protection explicit could help. However, such a metric should not be a single global circular economy metric because such a metric would fail to understand interlinkages relating to the different, material-specific systems. Therefore, metrics should cover specific materials, for instance metals or food, and be based on an in-depth analysis of their whole value system. The interviewee mentioned the report on the battery value chain[6] elaborated by the Global Battery Alliance as an example of such a material-specific metric. This report analyses metrics on materials in and production of batteries thoroughly, while also identifying specific levers to create circularity and optimise the value system, which in turn could lead to up to 30% GHG emission reductions.

The interviewee for resources in AP made reference to a similar figure from IRP that more than 50% of GHG result from resource use and hence sees a potential in all proposed measures to have an impact on GHG emissions. However, the interviewee thinks it would be necessary to take a look at the sectoral composition effects of many of the proposed interventions in order to estimate such reductions and assess which one would have the highest impact. The interviewee did not want to make estimations without having the necessary data at hand.

Fostering resource-efficient and circular buildings was also considered relevant for climate protection in LAC, where discussions on sustainable buildings currently focuses on water and energy efficiency potential of new buildings as a ways to reduce emissions.

[6] See World Economic Forum (2019) - A Vision for a Sustainable Battery Value Chain in 2030 – Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation http://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf

As a general statement, interviewees recommended that a holistic view is needed on climate and resources or in other words: economic growth and consumption patterns have to change and need to promote climate protection and resource conservation.

3.8 Limitations of the interview approach

By conducting interviews with experts on climate protection and resource conservation policies who work directly in the different regions, we managed to capture relevant first-hand insights about potential policy priorities regarding the identified policy measures. One of the main advantages of choosing this method has been the possibility to discuss relevant aspects of how a policy pathway could be developed over time to implement the measures in the different regions. However, there have been various limitations regarding the interviews.

Certain remarks of the interviewees, for instance regarding concrete examples of actions that governments in the regions have already taken or specific conditions that would be necessary to implement instruments that the interviewees proposed were seldom discussed. Furthermore, due to time constraints, it was difficult to go more in depth in one measure at the risk of not managing to cover all the questions. Another difficulty was the fact that the information we provided to the interviewees about the measures was purposefully brief, as we wanted to reduce the risk of reducing willingness to cooperate if we provided too much text to them.

As we focused mainly on experts working on international organisations with very tight schedules, it was imperative to concentrate the time that they spend collaborating with us in the interview and not reading lengthy background information. The trade-off was that interpretation that interviewees made of particular measures was often focused just on certain specific aspects (e.g. instruments) of the measure, often because they were not aware of other aspects that were included in the measure. For example, the interviewee for resource conservation in Asia-Pacific pointed at the need to have a measure focused on material efficiency in manufacture, while this was already included in measure 3 (designing products and business models for material efficiency and long service life). However, the discussion centred on circular business models rather than on eco-design and material productivity, even though all aspects are part of the measure. The comprehensiveness of the measures was therefore often not dealt with entirely due to time constraints.

Moreover, the background of the interviewees varied also considerably and in some cases it was not possible to differentiate whether the interviewees spoke about certain topics more because they had more expertise or because they were more relevant for the region. This limitation has also had implications for the assessment of the most relevant measures. In order to assess the relative relevance, the interviewees were asked to name their top three measures. Answers to this question varied considerably, as some interviewees provided more than three top measures, did not specify order of relevance or did not provide a selection of top measures at all. Thus, this assessment relied also on the spoken evaluation of each measure's relevance expressed by the interviewees throughout the questionnaire.

Moreover, it is important to mention that the interviews did not work as a back-casting exercise that could propose a concrete sequence of policy developments in the different regions. However, the gained insights can be used to adapt the modelling of measures and provide a parallel overview of important characteristics on all regions for measures of both climate and resource conservation parallel. By offering this general overview, the results from this report expand the available information on these two topics, which are generally found as separated fields and usually only for particular regions, mostly in the global north.

4 Lessons learnt and outlook

Overall, the regional analysis portrays a mosaic of different climate and resource policy pathways, starting from differing levels of policy ambition and socio-political feasibility. Different policy pathways start from a need for more awareness raising and education for the population in most regions (developing and developed alike) to creating the right and enabling infrastructures (from a stable grid to waste management infrastructure to safe outdoor leisure activities and public transport). Diets prove a main focus of both climate protection and resource conservation with meat and fish based diets culturally important in many regions or on the rise in AP with a middle-class. Urban areas in some regions show a countertrend of vegetarian and vegan diets emerging.

Renewable energy potential in all regions is large, but inexpensive and easily available fossil fuels, in particular oil, gas or coal, as well as infrastructure and political systems poised to perpetuate the use of fossil fuels pose formidable challenges to using renewable energy sources. Furthermore, in many regions the electrical grid is weak and electricity outages are frequent – hence, additional infrastructure investments into the grid and advances in energy storage technology are needed to increase electrification and to accommodate a larger share of renewables. Therefore, where a shift to 100% renewable energy might not be feasible or only in the long-term, other technologies for decarbonising fuel use (e.g. carbon capture technologies) might constitute an important milestone on the path towards 100% renewable energy. Then, electrification based on decentralised, renewable energy can effectively help reducing many regions' dependency on imported fossil fuel to power industry, the service sector and transport.

Buildings are in focus in regions with either high urbanisation rates, as in AP, or where building standards for energy (and material) efficiency are low or lacking. Climatic and socio-economic changes are expected to increase the demand for heating and cooling in buildings in many regions, thus making a more energy efficient and low-emission building sector imperative. In this context, using renewable energy to service heating and cooling needs seems key. In general, ensuring zero-emission and energy efficient buildings is a lot easier for new buildings than for the existing building stock. Regarding resource conservation, buildings are not considered a key focus in many regions apart from water and energy saving. Adding a focus on secondary materials, a better use of CDW for recyclates and also on (alternative and low-carbon) building materials, which improve both quality and life-time of buildings, appears relevant. Where large floor space or building area per person is an issue, as in the USA, lifestyle changes and sufficiency also become an issue in the building sector, beyond diets and general consumption patterns.

Overall, lifestyle changes and sufficiency appear very promising, yet very difficult to impossible to implement in the current political economy and social debates. Culture and tradition counteract such changes, particularly regarding meat consumption as a(n emerging) status symbol on culturally deeply rooted, but both the younger and in urban population show trends towards more sustainable lifestyles, e.g. vegetarian and vegan diets. However, this is far from mainstream in any region and also seems associated with both urban areas certain education levels. Where these prerequisites are not met, e.g. in many rural parts in Africa and AP, dialogue and consultation need to be fostered to involve, and infrastructure provided to enable, people to make changes. In this context, interviewees suggested to go through popular or religious figures to make such changes something aspirational and credible, but framing dietary changes as a health-related option and not as an attack on the meat or diary industries, nor on those consuming their products. A similar approach could be tried where tradition promotes food waste generation due to a culture of preparing and serving more food than could possibly be eaten. Overall, using role models to make behavioural changes towards more sustainable lifestyles more aspirational and relevant to people emerged as one central way forward.

While climate change perception in some (developed) regions does not (yet) lead to acceptance for climate protection policy, it starts shaping emotions (awareness that own behaviour is not good for the environment, but not in the sense of public pressure, e.g. flight shaming) – however, this is apparently not strong enough to challenge or change habits. Instead of, or maybe in the long term in addition to, climate change, air and water pollution are more directly relevant to people in some regions and also enjoy greater acceptance. In the same vein, plastic pollution emerges as a ubiquitous problem that is easily visible and widespread in many regions – and even if plastic pollution of the environment is not widely visible (e.g. in the US), plastics production and plastic waste management are considered a core area where improvements are needed. Not only appears waste management towards a circular economy complicated by insufficient infrastructure, but also by lacking perception of relevant business cases and business models as well as by lacking consumer awareness of the value of used products.

Similarly, consumer preferences for cheap and (the) new(est) products create path dependencies limiting repair and re-use and also seem to cause a decline in repair and re-use cultures in many regions. Furthermore, they such consumer preferences also seem to legitimise product design that centres on designing for first service life and not for durability, reparability and recyclability. Therefore, eco-innovation and innovation for sustainability might not rank high on political and corporate agenda, thus explaining low available funding for such innovation.

Awareness raising thus was considered essential in all regions to help paving the way for more sustainable behaviour and consumption choices. Regulation was also considered important as part of a policy mix, particularly regarding buildings (e.g. standards). Insufficient personnel for enforcement of legislation emerged as a key challenge for fostering legislation in many developing regions. Overall, market incentives were considered a key means across regions, but instead of using negative incentives, which in particular in the case of taxation would

- face strong resistance from industry lobbies and the public at large, and
- require well-functioning administration with well-trained personnel and transparent ways for using tax revenues,

positive incentives should be used that make sustainable options, circular business models and secondary materials relatively cheaper, more attractive as well as easier to create and access. Here, fostering eco-labelling, green public procurement and extended producer responsibility policy appear relevant. These could also facilitate businesses to develop more circular and low-carbon business models.

In order for businesses to do so, they would also need an easy to understand and use metric to assess and communicate the benefits of their sustainable business models. Making benefits of circular business models explicit and ready for communication would need to create metrics around specific materials, for instance metals or food, based on an in-depth analysis of their whole value system. Looking at the report on the battery value chain[7] elaborated by the Global Battery Alliance can serve as a good practice example here. This report analyses metrics on materials in and production of batteries along global value chains and identifies levers to create circularity and optimise the value system. Eventually, this turn could lead to up to 30% GHG emission reductions, thus showing the large climate protection potential of resource conservation and a circular economy – a relevant aspect of the climate-resource-nexus.

[7] See World Economic Forum (2019) - A Vision for a Sustainable Battery Value Chain in 2030 – Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation http://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf

In general, the climate-resource-nexus did not feature prominently in the interviews, likely because interviewees only seldom dealt with interactions between climate protection and resources conservation measures in their professional environments. Nevertheless, the main aspects of the climate-resource-nexus identified from the analysis of scientific literature (see chapter 2) also emerged from the interviews:

- Shifting to renewable energy and increasing electrification requires not only certain (partly scarce) raw materials, but also brings with it the need for further infrastructure development. Consequently, demand for certain materials will be increasing (while decreasing for fossil fuels) and a full lifecycle perspective is needed to assess whether there will be overall environmental and climate benefits or not.
- Reducing the need for virgin materials and increasing the use of secondary materials across industry sectors and consumers also reduces energy needs and GHG emissions. The same holds for lifestyle changes shifting towards greater use of repair and re-use as well as towards vegetarian and vegan diets.

However, compared to the growing body of scientific perspectives on the climate-resource-nexus from almost a decade, the nexus appears to only recently having started to become relevant in international administrations and policy.

In our view, the findings from this study allow making the modelling and associated scenario assumptions regionally more robust. Here, the findings can help designing the model towards modelling different policy approaches at varying points in time in the future in different regions. Thus, the kind of policy interventions can be adapted per region to merge into an overarching policy pathway over time covered by the model.

Furthermore, the mechanisms of how climate protection and resource conservation policy interact, both in terms of synergies and trade-offs, can be detailed further.

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