DECOUPLING GROWTH FROM RESOURCE CONSUMPTION

BACKGROUND PAPER
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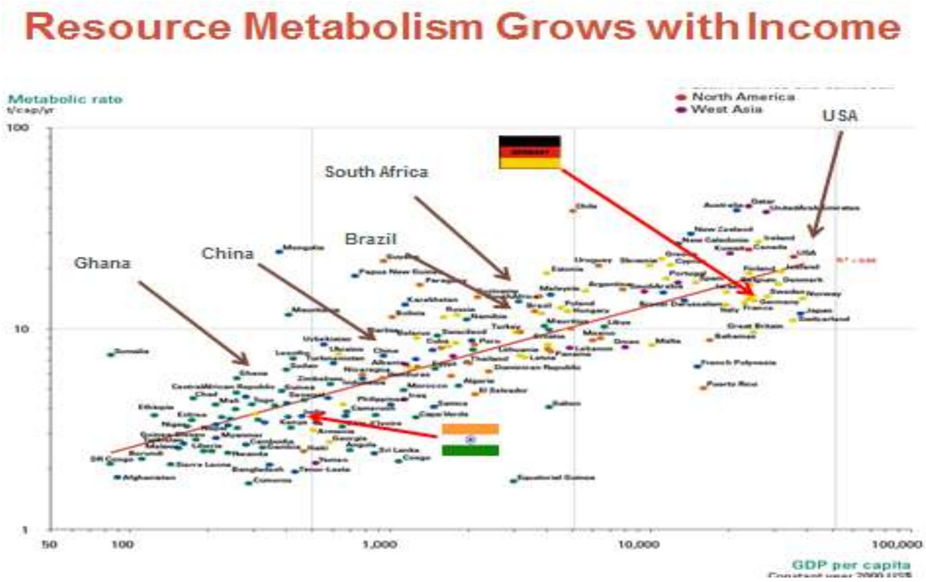
1 INTRODUCTION

Decoupling has become a buzz word signifying resource efficiency as a key strategy for creating a green economy, which in turn is considered by many to be one of the keys to sustainable socio-economic development. In this perspective it is important that we understand

- the need for decoupling and its implications on a global scale - for developed as well as developing countries and the specific challenges and opportunities facing them[1]
- the basis for defining the concept and designing metrics that can have universal applicability, recognizing the wide range of economic contexts, resource endowments, and human aspirations that characterize the global economy

This paper starts with basic concepts and definitions of decoupling.



2 DECOUPLING CONCEPTS AND DEFINITIONS

2.1 Basic Concepts and Definitions

Decoupling in its formal sense means removing the link between two variables. This paper focuses on decoupling resource use from economic growth. The International Resource Panel[2] distinguishes between resource decoupling and impact decoupling.

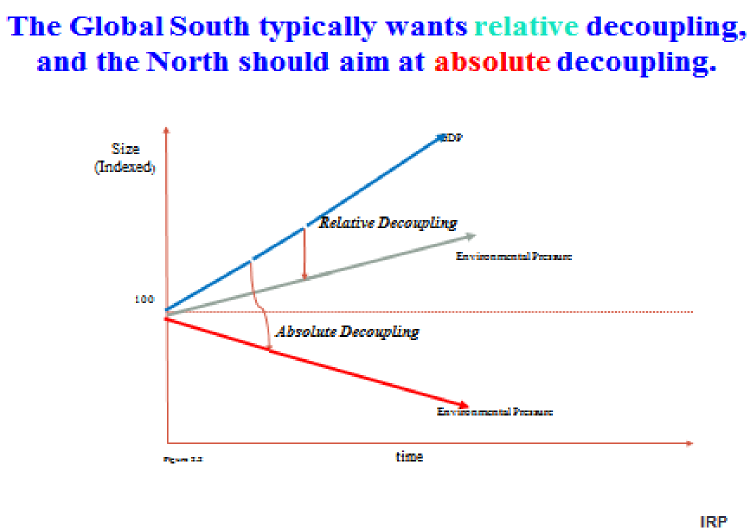
- **Resource decoupling** (or increasing resource productivity) means reducing the rate of use of (primary) resources per unit of economic activity. This understanding of 'dematerialization' is based the concept of using less material, energy, water and land for the same economic output, and it is connected with an increase in the efficiency with which resources are used. Resource decoupling seeks to alleviate the problem of scarcity and responds to the sustainability challenge of intergenerational equity by reducing the rate of physical resource depletion, while simultaneously helping to reduce costs by raising resource productivity.
- **Impact decoupling** (or increasing eco-efficiency) means raising economic output while reducing negative environmental impacts that arise from the extraction of required resources (such as

[1] See Rockström et al. (2009)
[2] http://www.unep.org/resourcepanel/

groundwater pollution due to mining or agriculture), production (such as land degradation, wastes and emissions), use of commodities (such as transport resulting in CO_2 emissions), and in the post-consumption phase (wastes and emissions). Methodologically, these impacts can be estimated by life cycle analysis (LCA) in combination with various input-output techniques. However, it is very demanding to measure impact decoupling at an aggregate system level such as an economic sector or the national economy. Many environmental impacts need to be considered, their trends may be quite different or not even monitored over time, and system boundaries as well as weighting procedures are often contested. Impact decoupling means using resources better, more wisely or more cleanly. Reducing environmental impacts does not necessarily have a mitigating impact on resource scarcity or production costs, and may even sometimes increase these.

The term **double decoupling** refers to delinking economic growth from resource use and from environmental impacts.

Another important distinction has to be made especially from a country specific macro perspective between ‘relative’ and ‘absolute’ decoupling.



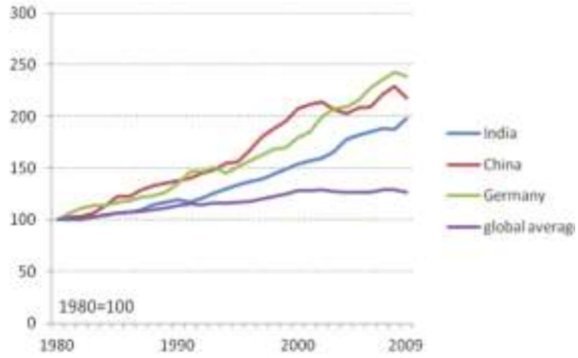
Relative decoupling of resources or impacts means that the growth rate of resource use or impacts is lower than the growth rate of a relevant economic indicator (for example GDP). Such relative decoupling seems to be fairly common.

Absolute decoupling means that resource use declines, irrespective of the growth rate of the economic driver. Only very few countries, and even those over very short periods, have actually achieved such an overall decline of resource consumption within a certain time period, e.g. Germany between 1995 and 2005, which was mainly due to a significant decrease in construction and coal mining products[3].

[3] ETC/SCP 2011

Over the past several decades, economies in general have grown faster than their resource consumption, and in some countries significantly so. While global resource efficiency grew by around 27% between 1980 and 2009, it rose by 98% in India, 118% in China and 139% in Germany (See Figure 1) [4].

Figure 1: Improvements of resource productivity (GDP / DMC) in India, China, Germany and the global average, 1980 and 2009



Source: calculation based on Dittrich 2012, SERI 2011 and Worldbank 2011. Measured as GDP (ppp const. 2005) per DMC

2.2 Indicators

The results of decoupling analysis depend on the choice of indicators. A comparison of different indicators currently being studied shows that the strategic objectives for resource use in environmental policy up to now tend to be general in nature, with the exception of GHG emissions and renewable energy. The debate on the "right set" of indicators continues, but should hopefully be settled soon by developing pragmatic, measurable, reliable ("richtungssicher") and easy-to-understand indicator sets for politics, business and the civil society.

Another challenge is the question of how quantitative indicators should be used for target setting and what they mean in the context of global regimes aimed at reducing resource consumption. Up to now there is little political consensus among national governments for setting quantitative targets both nationally and globally. This is not only because of a general reluctance to make commitments on indicative, much less binding, quantitative targets (as in the case of climate negotiations), but also for lack of definite measurement methodologies. The simplest input and consumption indicators used for international comparisons are Direct Material Input (DMI) and Domestic Material Consumption (DMC), which only take direct flows into account. A second set of indicators - Raw Material Input (RMI) and Raw Material Consumption (RMC) - try to take indirect flows also into account. Total Material Requirement (TMR) and Total Material Consumption (TMC) are the most comprehensive indicators, incorporating both indirect flows and unused extraction.

Decoupling can be measured by comparing one of these indicators with economic indicators such as GDP over a given timeframe. Much of the data presented in this paper uses DMC because it is most widely available on a global scale. The European Commission proposes to use RMC as a headline indicator in the future[5]. Data on TMR and TMC are still limited, although gradually becoming available[6].Not only is the denominator, which represents resource consumption, currently contested, but also the numerator, which is meant to be a measure of economic well-being. For example the International Resource Panel stresses that the GDP indicator on its own is an inadequate metric of genuine progress and in any case is heavily dependent on measures that depend on the quantity of resources used, which in turn depends on numerous economic, geopolitical and other factors, stating that *"Other indicators are needed to complement the GDP indicator in order to generate a more balanced understanding of development."*[7]

In general, the shortcomings of GDP as an indicator of quality of life are now widely accepted and are increasingly challenged not only by the research community but by politics as well.[8] At the end of the paper this point is taken up for further research in the outlook.

[4] IFEU et al, 2013, p.39ff
[5] J. Potocnik speach „Are we moving to a resource efficient future". 5 November 2013, Brussel.
[6] See the Annex of O'Brien et al. (2012) for an overview of countries with available TMR data based on H. Schütz, Wuppertal Institute.
[7] UNEP 2011, p. 35.
[8] See for example Stiglitz et al. (2009), German Enquete Commission (2013), and Constanza et al. (2014)

3 THE NEED FOR DECOUPLING

3.1 Unsustainable Global Trends

Global economic and social development over the last two centuries has been largely achieved through intensive, inefficient and unsustainable use of the earth's finite resources. Over the course of the 20th century global resource extraction and use increased by around a factor of 8[9]. Global population grew around half as fast and GDP grew at a significantly higher rate (by a factor of 23). The resource category with the highest growth rate was construction minerals (which grew by a factor of 34), followed by industrial ores and minerals (factor 27) and fossil fuels (factor 12). The extraction and use of biomass increased by a factor of 3.6, portraying a clear shift from non-renewable mineral resources. to renewable biotic ones.

The level of resource consumption differs dramatically across the world. On average, around 8.5 tonnes DMC/person were consumed globally in 2008[10]. In that year, India's per person consumption was around 4 tonnes/person whereas Germany consumed around 14.8 tonnes/person. Two key factors are thought to account for the variation across countries: development status and population density. Industrial countries generally have an above-average metabolic rate and countries with low population density typically consume more than countries with high population density (e.g. Finland, the US and Australia have a metabolic rate around twice as high as the European average). Lower requirements of densely populated regions may have to do with reduced per capita infrastructure needs (more efficient use of space for housing and less transport needs) and more efficient supply of heat for homes[11].

The efficiency of resource use is also quite different across the globe. Globally, productivity ($GDP_{US\$\ PPP\ cont.\ 2005}$ / tonne DMC) was US$ 952 in 2008. For India it was US$ 696 and for Germany US$ 2,278[12]. This is indicative of a larger global trend: in most cases, the countries that consume the most are also the most efficient when it comes to creating value from resource use. As such, efficiency as measured by GDP per tonne of DMC is not correlated with aggregate resource use and therefore is not by itself a good indicator of sustainable development.

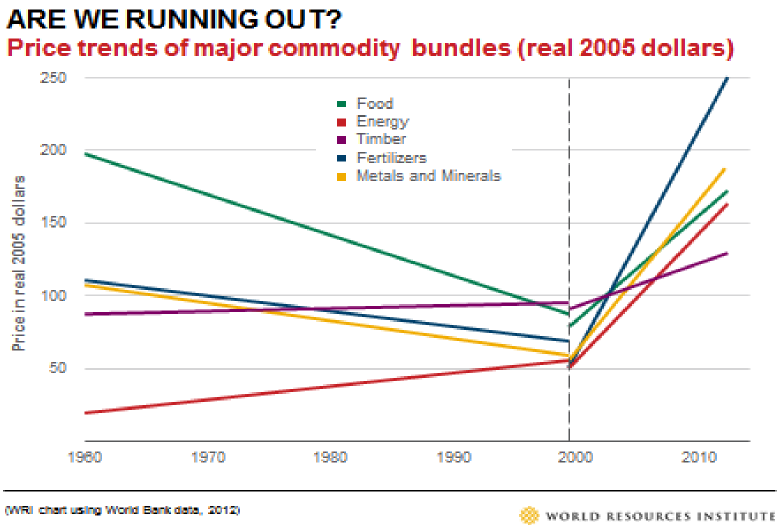
Given a world population that grows by 200,000 people each day and especially a rapidly growing global "middle class" associated with resource-intensive consumption patterns, the demand for natural resources will continue to increase. The International Resource Panel developed a scenario in which the average metabolic rates of industrial countries remains stable and developing countries "catch up" to the same rate by 2050. This scenario would result in a global resource need of 140 billion tonnes, or around 2.5 times the current demand for natural resources[13]. According to the Global Footprint Network, if current economic and production trends persist, we will need the equivalent of two Earths to support us by 2030 (Global Footprint Network, 2012). The World Business Council for Sustainable Development estimates that significant improvements in resource efficiency will be needed by 2020 and they will need to increase by 4 to 10 fold by 2050[14]. The global economy thus needs to reduce dependence on primary resource extraction, while still enabling us to lead satisfactory, fulfilling lives.

These scenarios offer clear indications that current levels of resource consumption exceed what is considered sustainable; at least 3 of 9 identified planetary boundaries have been exceeded and others are

[9] UNEP 2011, accounting in terms of only used extraction
[10] Dittrich et al. 2012a
[11] UNEP 2011
[12] Dittrich et al. 2012a
[13] UNEP 2011, p. 28.
[14] WBCSD 2010

dangerously close to scientifically *'safe'* thresholds[15], 60% of the world's major ecosystems that ensure the reproduction of renewable resources have already been degraded or are being used unsustainably[16].

While the challenges of resource depletion and environmental disruption are global challenges, they affect people differently in different regions of the world[17]. This is especially obvious with regard to food and water. If current trends continue, 1.8 billion people will be living in water-scarce regions by 2025 and two-thirds of the world population could be subject to water stress[18]. In no other decade, except possibly just after World War II, has the world witnessed a pattern of steady and steep food price increases, such as the one we have experienced recently. As a result of the food price rises since June 2010, there has been a net increase in the number of people living in extreme poverty of around 44 million, mostly in low- and middle-income countries[19]. *"If predictions of several organizations, such as the OECD or FAO, turn out to be true, there will be two decades of steadily rising prices – something that has not happened before"*[20].



The resource challenge increasingly affects security issues, e.g. an increasing number of local and regional conflicts have erupted from the competition over natural resources and the limitations following their use[21].

3.2 Key Sectors for Decoupling

The potential to use resources more efficiently is vast. The question is, how can the hot spots and priority areas for change be identified? At the sectoral level, input-output analysis can pinpoint sectors and product groups that are especially resource intensive. Recent research has revealed that five product groups are responsible for the majority of resource use at the final consumption end of Europe's economy[22]:

- construction
- food, beverages and tobacco
- agriculture, forestry and fishing
- electricity, gas and water
- coke, refined petroleum products and nuclear fuels.

15 Rockstrom et al. 2009, p. 472.
16 MEA 2005
17 UNEP 2011, p. 3.
18 EEA 2010
19 World Bank 2011
20 UNEP 2014, p. 37
21 Bringezu and Bleischwitz 2009, p. 12.
22 According to calculations of the Wuppertal Institute in ETC/SCP 2011. Calculations refer to 9 EU countries for 2005: Austria, Czech Republic, Germany, Denmark, France, Italy, Netherlands, Portugal and Sweden.

In the Indian context also, construction, industry (especially manufacturing and power generation) and agriculture are energy and resource intensive sectors. These findings are supported by other studies listing construction, agriculture, and food & beverages as main material consuming sectors[23]. Regarding their economic performance, the identified five product groups represent 18% of the consumption expenditure and two-thirds of resource use in the examined EU countries in 2005. This also makes them some of the most resource-intensive product groups. It implies that channelling investment towards less resource intensive goods and services (e.g. education has low resource intensity) can enhance decoupling. Nevertheless, the indirect material and resource base of services would need to be better accounted for.

Food is the most resource-intensive product (highest resource use per unit of expenditure) in the EU and its resource intensity has been increasing since 1995[24]. Food waste is a serious challenge: the FAO estimates that consumers in Europe and North America waste 95-115 kg/year. This is 10-15 times more wastage as compared to consumers in Sub-Saharan Africa and South/Southeast Asia[25]. It also reveals a considerable potential for reducing impacts by combating food waste, through education and waste prevention campaigns. Modelling results reveal by decreasing the amount of food wasted at retail and household levels by 15-20% and reducing meat consumption by around 25% (to a minimum of 70 kg/person/year) in Europe, North America and Oceania by 2030, around 105 Mha of cropland (or a 6% reduction) and 1,062 Mha of permanent grasslands (or a 29% reduction) could be saved[26]. There is also considerable potential to reduce food loss at production and transport stages in developing countries.

The resource intensity of housing is also high, but has been decreasing since 1995 in the EU[27]. One of the key challenges related to lowering the primary resource requirements of construction is material recycling, and it has been pegged as one of the most important activities for material savings at the economy-wide level[28]. Experiences in Germany and other EU member states demonstrate the power of regulatory compliance to drive innovation in the recycling sector for recoverable construction and demolition minerals: a C&D landfill ban forced the market to innovate to create new economically beneficial recycling applications, and led e.g. in the Netherlands to a 25 % decrease of waste to landfills from 1995 to 2006[29]. The Indian cement industry has decreased its emission intensity from 1.04 Mt CO2/Mt cement in 1995 to about 0.79 Mt CO2/Mt cement in 2007 due to addition of industrial waste like flyash and blast furnace slag[30].

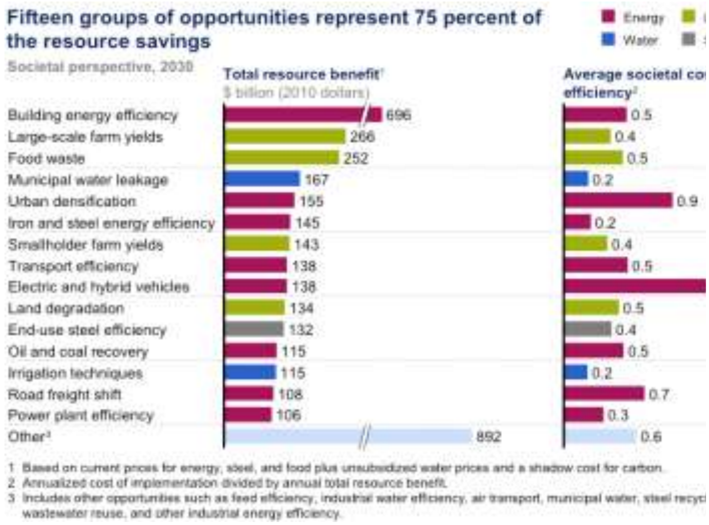
Understanding how to improve resource efficiency in a smart way catering to specific sectors is crucial to achieving economy-wide absolute decoupling. At the national level, the resource-intensity of sectors varies, sometimes significantly. Different natural, economic, and structural conditions affect efficiency potentials in different countries. More studies are needed to assess the potential and trade-offs of resource efficiency in sectors[31].

While this kind of research is certainly useful and necessary for identifying priorities, it should be noted that it does not necessarily mean that interventions are needed for those sectors alone. For instance, in Germany, the average material requirement per € 1,000 of value added is 44 kg in service sectors compared to 557 kg across all economic sectors and 1,861 kg in manufacturing industries[32]. Pursuing a resource-efficiency transition strategy does not imply focusing on just manufacturing alone (although there are abundant low-hanging fruit opportunities in manufacturing). This is because there would be no services without the use of products, machines, and infrastructure. In other words, aiming for service-based economies might shift resource-intensive activities elsewhere, but does not terminate them. As such, the focus of a decoupling transition must be to develop an economic system capable of providing a

[23] SERI et al. 2009, BIS 2011
[24] ETC/SCP 2011
[25] Gustavsson et al. 2011
[26] Wirsenius et al. 2010
[27] ETC/SCP 2011
[28] Mudgal et al. 2011
[29] Dawkins and Allan 2010
[30] Parikh, 2011
[31] O'Brien et al. 2012
[32] Statistisches Bundesamt 2009

high standard of living to its citizens based on a sustainable level of primary resource use. McKinsey[33] identified 15 groups of opportunities for fostering resource productivity and calculated their total resource benefit as well as their cost/benefit ratios. It turns out that about 75% of the total resource savings potential in 2030 could – taken a societal perspective – be implemented with an attractive cost-benefit ratio between 1.2 and 0.2 (See Figure 3).

Figure 3: Resource Saving Opportunities by 2030



Source: McKinsey 2011

While there are huge potential gains of adopting resource efficient methods, making such choices very attractive in principle, many barriers and market failures will impede its implementation in the market. Thus, global cost/benefit-analysis is only one step and must be complemented by in-depth analysis of country, sector, technology and actor specific barriers and how a targeted mix of policies and measures can be developed.

4 DECOUPLING: CHALLENGES

The *need* for global decoupling has been well-established, but the question of *how* to foster decoupling is more difficult. Differentiation is needed with respect to countries in different development stages as well as concerning segments of the economy and consumption patterns within and across countries.

4.1 The Dichotomy of Economies

The global challenge today is to lift one billion people out of absolute poverty and to set the pathway for meeting the needs of nine billion people in 2050 while keeping climate change, biodiversity loss and health threats within acceptable limits ("planetary boundaries"). For present and future well-being, there is a need to achieve sustainable resource management by decoupling natural resource use and environmental impacts from human well-being. Economic progress is still needed in many regions of the world to fight poverty, but this growth needs to happen within the global boundaries of resource use in order to be sustainable. While the basic challenge of decoupling is comparable across the globe, the targets and the pathways are quite different depending on their consumption patterns and economic development. It has been estimated that the per capita ecological footprint of the richest one per cent people in India is 17 times that of the poorest 40%[34]. Although there are many different national contexts,

[33] McKinsey (2011)
[34] Churning the Earth by Ashish Kothari

it is convenient to differentiate decoupling concepts at least for two broad categories of the global economy i.e. the developed and the developing economies.

However, this is no longer a geographical divide, especially because the *'developed'* characterized by high consumption levels, enjoying high levels of material, physical comforts and access to opportunities co-exist with *'underdeveloped'* poverty stricken communities in almost all geographies today. This results in excessive demands and unsustainable lifestyles among the richer segments, which places immense stress on the environment. The poorer segments, on the other hand, are unable to meet basic needs like food, health care, shelter and education[35]. However the *'proportion'* of developed to developing economies in any nation state does not appear to be an indicator of robust operational / governance institutions and implementation capacities.

The developed economy, typically representative of affluent lifestyles and consumerism, is exploiting a large share of the global natural resource base. They represent the *'consumption society' (new consumer classes*). These unsustainable lifestyles are based on and are intricately interwoven with the consumption and production patterns of the current economic development model of the West[36]. The challenge is *maintaining and distributing prosperity* more equally while finding ways to dematerialize the economy and society through absolute decoupling.

The side-effects of this development model, which the North adopts and the South emulates, is likely to have worse implications for the natural resource base in the face of urbanization and rapid economic development now occurring in the emerging and low-income economies. Across the world, energy and resource intensity of meeting needs and aspirations through material consumption are escalating steadily in urban spaces. While the significant improvement in overall quality of life in developing countries is a remarkable achievement, this structural transformation is fostering Western aspirations and lifestyles of consumerism through media as well as trade and market policies. The increased presence of multinational corporations, luxury brands, international hospitality chains and promotion of material-intensive lifestyles stand testimony to this fact in India and other economies of the global South. Given this scenario, it makes sense for India to adopt green and inclusive economic systems for sustainable production and consumption at this juncture of its growth story[37].

On the other hand, developing economies, with large numbers of poor living in substandard conditions, are both agents and victims of environmental degradation. They represent the '*subsistence society'* with high 'direct dependence' on natural resources for livelihoods and basic needs. A reduction in stocks of natural capital and flows of ecosystem services disproportionately harms the wellbeing of the poor and the resilience of their communities. Therefore, the steps towards decoupling move towards relative decoupling by improving resource efficiencies while minimizing environmental impact. However poverty can also exert a negative impact on the environment. In their quest for food security and basic need provision, the poor overuse limited resources available to them resulting in environmental degradation further reinforcing this 'downward spiral' or 'vicious circle'[38]. The poor are forced to make trade-offs between immediate household basic needs requirements and environmental sustainability both in production and consumption resulting in coping mechanisms that rely on only capital available to them -- natural resources. This makes them more vulnerable to impacts of environmental degradation, including degradation wrought by others.

In developing economies, the challenge is how to *foster* an economic system that meets the needs of people in a way that is compatible with long-term resource conditions, rather than copying mindlessly the unsustainable production and consumption patterns of the developed economies. This means taking advantage of leapfrogging opportunities, such as energy efficiency in new buildings, developing sustainable transportation systems and developing infrastructure for better waste recovery.

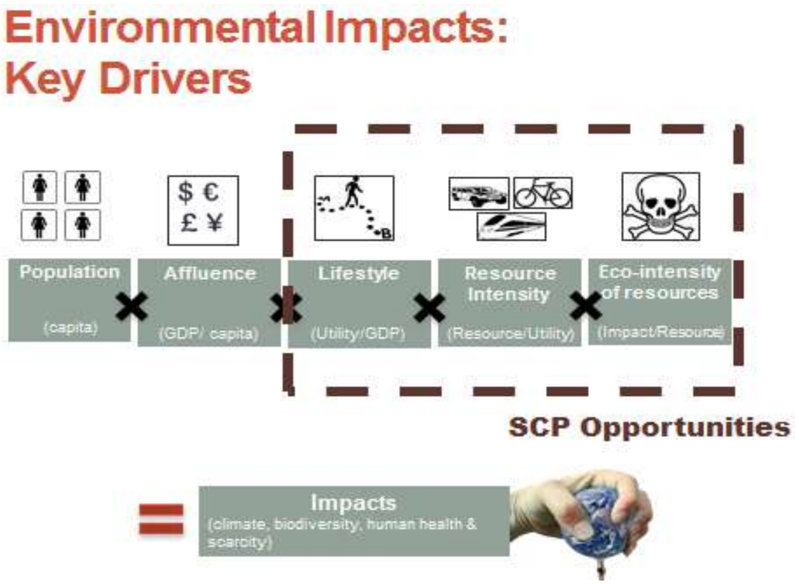
[35] UNEP 1992
[36] Mont 2007
[37] IGEP 2013, India's Future Need for Resources
[38] IFAD 2011

In both cases, the issues of resource decoupling will need to incorporate the triple thrusts of Resource Efficiency, Resource Recycling and Resource Substitution (use of waste resources instead of virgin materials). Each of the above can drive economic value creation and has immense potential at the micro small and medium enterprise (MSME) scale. This has a strong link to inclusive economic growth and value retention, especially suited in the context of developing economies such as India whose economic backbone is based on this sector with 80% of the workforce placed here. The MSME sector offers additional co-benefits such as fostering *'inclusiveness'* and *'increased self-dependence'*, local capacity building and increased diversity in livelihoods thus reducing vulnerabilities and enhancing adaptive capacities.

4.2 Formal Illustration of 'Common but Differentiated Challenges of Decoupling'

It is clear that a global transition in natural resource consumption will need an **absolute decoupling** in developed *(*industrialized) countries (i.e., reduction of aggregate resource consumption) together with a **relative decoupling** in developing countries (i.e., reduction of growth *rates* of resource consumption) until such time as the developing countries attain acceptable standards of living, after which they, too, will have to adopt measures to achieve absolute decoupling.

These common, but differentiated opportunities and challenges of decoupling in developed and developing countries can be made clearer by referring to Paul Ehrlich´s identity[39]:



The formula[40] I = P x A x T (I=Environmental Impact; P=Population; A=Affluence per capita; T= Technology) can be interpreted as follows: Taking resource use (R)[41] an the indicator for I, Y/P (per capita income) as the indicator for *'affluence'* and T as the indicator for resource intensity (reciprocal of resource productivity) then the relation R = P x Y/P x R/Y (reformulated in growth rates ($w_R = w_P + w_{Y/P} + w_{R/Y}$)) leads to a simple conclusion: With a positive growth rate of population (w_P) and for per capita affluence ($w_{Y/P}$) the global environmental impact can only be constant ($w_R = 0$) if the resource intensity decreases by the added growth rates (w_P)+ ($w_{Y/P}$).

The strategic message on a global scale is quite clear: The resource shortages and environmental impacts of resource use can become significant constraints on human progress unless we urgently find ways to

[39] Compare Hennicke and Sewerin (2008)
[40] UNEP 2011
[41] R may be measured by the TMR as a common global indicator for the environmental impact of resource use.

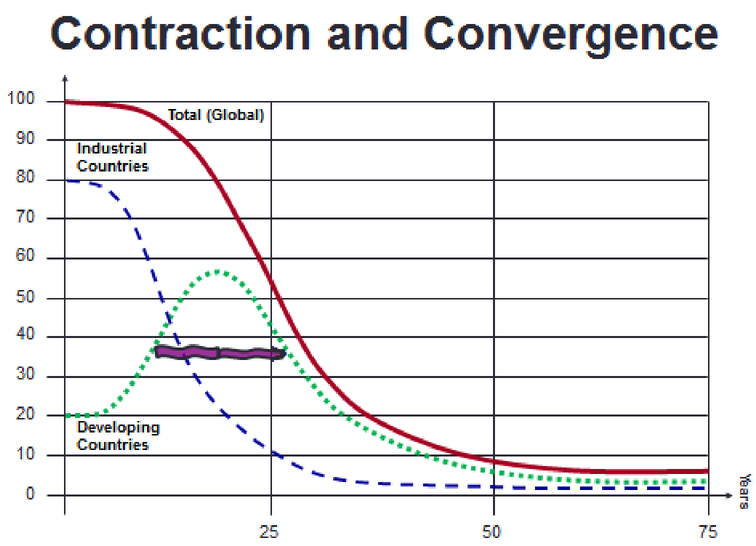
reduce the growth of population (P), accept lower standards of living (Y) and/or significantly raise resource productivity.

But this global perspective has to be differentiated at least according to development stages: Concerning the global environmental impact (I) differentiated for developed and developing economies.

- I_{IC} can be **absolutely** reduced in **developed countries** (IC; assuming constant population) if the growth rate of resource productivity is higher than the increase rate of per capita affluence
- I_{DC} can be **relatively** reduced in **developing countries** (DC; assuming growing population and high GDP-growth) if the growth rate of resource productivity is as high as possible to offset the necessary increase of per capita affluence.

This concept of "contraction and convergence" (also called "common, but differentiated responsibilities to save the planet") is crucial for evaluating the goals and the results of national resource policies in developed countries like Germany, emerging economies like India and elsewhere. The conceptual chart below gives three key messages:

1. **ALL** economies of the world must, in a relatively short time, converge to a per capita resource consumption that is sustainable, current best estimates indicating an allowance of somewhere between 6 and 8 tonnes per person per year;
2. Countries currently consuming natural resources above this level must by all means available (including technological, behavioural, fiscal, etc) bring their consumption down to this sustainable level as rapidly as possible
3. Countries currently under-consuming their quota will need to raise their per capita consumption to a level that meets the basic requirements for a healthy and productive life of their citizens and at the earliest stage feasible, then avail of the knowledge, technologies and changes in socio-economic behaviour to achieve resource efficiencies that enable them to *'tunnel'* through to an acceptable standard of living within the resource boundaries agreed to on an international level.



It will be noticed here that *'decoupling'* natural resource use from economic progress is a concept that is largely hinged on two basic parameters: *raising resource productivity and dematerialisation*, which is largely to be achieved through technological means (innovation, efficiency, substitution, product durability, miniaturisation, etc) and *reducing resource demand* which requires behavioural change on the part of individuals and societies (lifestyles, waste minimisation, sharing of underutilized infrastructure and assets, etc). Economic policies (taxes, incentives, temporary subsidies, etc) and regulations are available to encourage businesses and households to switch to more desirable development trajectories.

For reasons of political, cultural and other sensitivities, the first term in the Ehrlich Identity mentioned above, P (population) is generally not dealt with adequately, if at all. Clearly a world that has 10 billion inhabitants, as is projected for the end of the 21st Century by the United Nations statisticians will have rather different resource and environment consequences than one with, say 6 billion. Given the aging and decline of populations in some parts of the world and the high fertility and rapid growth continuing in other parts, no discussion on decoupling can be complete without an analysis of how human numbers will, in a humane and natural manner, come back into balance with the resource endowment provided by nature.

This discussion cannot therefore be complete without an analysis of the nexus between population growth, development and natural resource use. While normal analyses of these issues assume that all three parameters – population growth (i.e., human fertility and mortality), development (i.e., quality of life and livelihoods) and the health of the resource base (i.e., prospects for the future) – are exogenously determined (i.e., independent and taken as given by external factors), this is not strictly correct. There is ample evidence that human fertility, mortality, family size, etc. are very much determined by the other variables including health, education and jobs.

To achieve the required decoupling between the global economy and the resources of the environment, it is necessary to bring POPULATION into the calculation – particularly the impact of development and environment on fertility and family size. There is enormous evidence that improving the lives and prospects of poor people has an immediate and direct impact on their desire to have smaller families. The importance of this – and its greatest value – is that this is the one factor that brings the interests of the global North and the global South into direct convergence. And this means that the number one priority for the global community today is for every actor, governments, businesses and civil society to help accelerate investments and actions to remove poverty and create an equitable world. This set of issues is the subject of Annex 1 to this paper: *More is Less – The Hidden Path to Decoupling*. Annex 2, which is an essay written recently to honour Wolfgang Sachs, touches on the second important term in the Ehrlich Identity and deals with the Sufficiency aspects of Lifestyles.

4.3 Formal Illustration on Resource Protection and Jobs: A 'Knife-Edge'-Problem of Absolute Decoupling

In most countries of the North the acceptance of a strategy on absolute decoupling of GDP from the use of nature will be low if it is not connected with at least stabilizing or increasing employment. This can be taken as a necessary condition of sustainable development.

It can be demonstrated by a formal comparison of growth rates again that this condition – cet. par. – can be perceived as a societal '*knife edge'*- problem.

Using the following definitions,

- Labour productivity (LP) = Gross Domestic Product (GDP) / Jobs (J)
- Resource productivity (RP) = Gross Domestic Product (GDP) / Total Material Requirement (TMR)
- Energy productivity (EP) = Gross Domestic Product (GDP) / Energy (E)

a necessary condition for sustainable development - more jobs, less use of nature - can be demonstrated by the following:

Only if the growth rate of GDP > growth rate of LP → Employment increases

On the other hand:

Only if growth rate of GDP < growth rate of RP (or EP) → Resource use (or energy) decreases

Thus to meet the necessary condition of sustainable development the following formal inequation must hold:

Growth rate of LP < Growth rate of GDP < Growth rate of RP (example for annual rates: 1.5% < 2% < 2.5%)

Thus, focussing economic policies only on maximising *'economic growth'* without fostering resource productivity will not end up at absolute decoupling. On the other hand, the growth rate of GDP must be high enough if additional jobs were to be created with an average growth of labour productivity.

The formal inequations hold under cet. par. conditions. To alleviate this *'knife edge'* problem other strategic options like e.g. the reduction of average labour time, structural changes to a service/recycling economy, new models of wealth, lifestyle changes and sufficiency policies have to be taken into account.

4.4 The Decoupling Triangle

One basic challenge of fostering global decoupling by the increase of resource productivity is supporting micro-level activities that are compatible with long-term goals and conditions. This requires a systemic perspective and a way to link the micro level of where change happens to the macro level of where impacts are measured, policies are made and targets are set.

It also requires knowledge on how to cushion '*rebound effects*[42]' over time. For example, even though the technical feasibility of an **absolute** decoupling and a tremendous increase of resource productivity were demonstrated by scenarios and might be the aim of national resource policies, counteracting social and economic reactions (direct/indirect rebound effects; growth, structural and quantity effects) can *'eat up'* even massive increases in product, process or sector specific resource productivities. Therefore resource policies based on technology driven scenario analysis and respective policy mixes to overcome barriers and to disseminate advanced technologies should always be aware of these counterproductive side-effects. It is the triangle of **efficiency** ("more with less"), **sufficiency** ("less can be more") and **consistency** ("better than more") on which policies and measures for decoupling should be based.

At the end of the day, what counts from an ecological and ethical perspective is to **sustain ecosystem services for all peoples and generations to come**[43].

5 BARRIERS AND STRATEGIES FOR DECOUPLING

5.1 Barriers to Systemic Changes

There are a number of ways to classify barriers. As decoupling is about systemic change, we consider typical system failures, which include shortcomings in[44]:

- Firms—limited capability of companies to act in their own best interests; for example, through shortcomings in managerial and organisational capacity, learning ability or "absorptive capacity" or focusing on up front cost instead of life cycle cost analysis
- Knowledge Institutions—inadequacies in universities, research institutes, patent offices; rigid disciplinary orientation in universities (*silo thinking*) and consequent inability to adapt to changes in environment is an example of such a failure
- Networks—problems in the interaction among actors in the innovation system causing *transition failures* and *lock-ins*

[42] See for example Madlener and Alcott (2011). Here the term „rebound effect" is used in a general and pragmatic way to include e.g. direct/indirect rebound effects as well as growth, structural and quantity effects.
[43] This simplified definition summarizes the often cited Brundtland definition of sustainable development; the strength and impact of substitution between „nature" and „capital" (strong vs. weak concept of sustainability) can not be debated in this context.
[44] EIO 2012, Smith 2010

- Frameworks—gaps and shortcomings of regulatory frameworks, intellectual property rights (IPR), health and safety rules, etc., and other background conditions, such as the consumer demand, culture and social values

The symptoms of systemic problems include, for example, a low demand for secondary resources from companies and consumers due to a limited environmental awareness, lack of information and failure to recognise externalities in the price of primary resources. **Political risks** associated with market and structural failures make it more difficult for governments to act. In the context of decoupling, one of the key roles of a policy framework is to provide a level playing field for economic activity while safeguarding common goods, including non-renewable natural resources. However, difficult economic environments make short-term policies to boost economic growth, instead of experimenting with different pathways or leapfrogging. Distortions on international commodity markets, such as unfair trade with asymmetrical gains, illicit trade with critical minerals from conflict areas, market power of state-owned and other emerging miners on commodity markets and pre-emption of scarce assets such as rare earth minerals make the policy challenge more complicated.

Technology risks make it more difficult to find investments for clean technologies. Information asymmetries among investors, project developers and policy makers inhibit resource efficiency. Improved long-term orientation will help foster synergies between policy and technology transitions toward absolute decoupling and lower risk for investors. Facilitating multi-stakeholder dialogues on economy-wide targets for resource use would not only raise awareness but also pave the way for future investments and company activities.

5.2 Adjuncts in A Core Strategy in Decoupling

Past experiences suggest that structural change has been driven by '*waves of innovation*' converging technological potential with collective shifts in perception. The challenge is to create synergies between socioeconomic benefits and environmental objectives to overcome structural barriers such as systemic lock-ins and market failures. Decoupling will require changes across strategic adjuncts like knowledge, capacity, policy, technology and finance. It will require structural changes in business models, lifestyles and modes of governance and will primarily rely on a combination of changes gained through new alliances of fast-movers working together to demonstrate desirable alternatives to business-as-usual[45].

New types of knowledge are needed to understand, foster, manage and improve this transition. Sustainability research, for example, is a relatively new field that aims to take a more comprehensive and integrated (inter- and transdisciplinary) approach to creating knowledge about the interactions between humans and natural systems. Targets for decoupling resource use based on scientific knowledge in the light of risk and uncertainty are necessary. Participatory processes are essential in the production and usage of scientific knowledge.

Capacity in skills and innovation are required in both developed and developing countries. Among the most important internal barriers to material efficiency encountered by companies is a lack of knowledge and skills. Awareness on material efficiency and knowledge on how to create a successful green business model is low. Time is also a problem, especially in MSMEs with limited capacity to concentrate on activities outside of their core business[46]. In this sense, investment in awareness raising and skills development is an important precondition for promoting resource efficiency in companies. To this end, the structure of universities with rigid disciplinary orientation and institutional inertia needs to be revisited to equip the next generation of scholars, entrepreneurs and employees to handle challenges of the future.

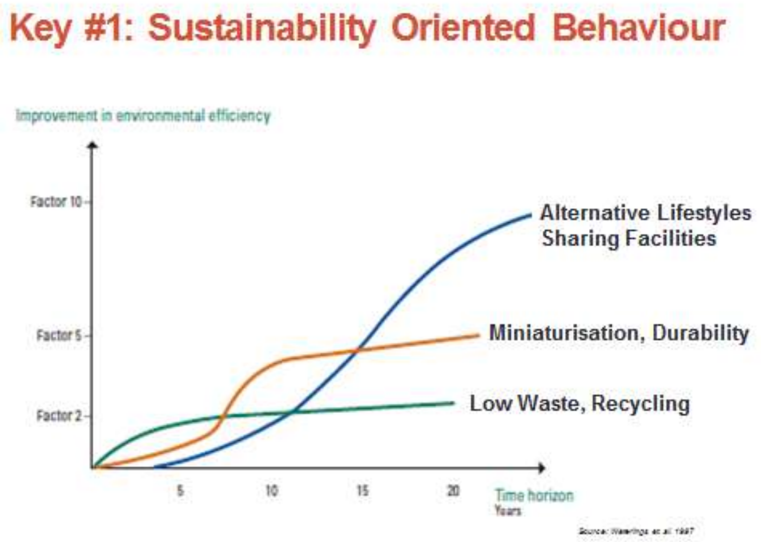
Policy needs to play a dual role for promoting decoupling. Policies need to build the framework and set an overall direction for change. This includes stating clear and binding targets for resource use and emissions

[45] EIO 2013
[46] Nordic Innovation 2012; EC 2011b

(related to planetary boundaries) and creating a level playing field for eco-innovators by recognising both economic and environmental costs and benefits of their activities. Secondly, policies provide support for eco-innovation through science, innovation and enterprise, as well as through green public procurement and public-private partnerships. Refer Chapter 6 for more examples of policies.

Technologies are expected to play a role in the shift to a resource efficient economy and the corresponding restructuring of industrial processes needed to modernise industry and foster competitiveness. Key enabling technologies exist in the areas of biotechnology, advanced materials, nanotechnology, photonics and micro and nano-electronics. Carbon capture and storage systems as well as systems of carbon capture and re-use have also been highlighted as key activities[47]. Application and adaption of information and communication technology (ICT) in construction, energy or transportation sectors has already led to radical innovation in the ways things are done. It is estimated that ICT can help mitigate around 13% man-made GHG emissions resulting from transport by reducing travel needs, influencing travel choices, changing driver and vehicle behaviour, increasing network efficiency and increasing vehicle load factor[48]. In the future, innovations like the internet of things, machine-to-machine communication and radio-frequency identification devices (RFID) could be used in collaboration with other sectors to develop new and creative applications. For example, RFID pads could be used to tag cars and buildings, with information on materials used in their production and how these materials can be recovered[49]. This would greatly enhance efforts toward urban mining and result in a wide range of positive economic impacts, especially on a regional scale. Nevertheless, there are also risks connected to the ever increasing expansion of ICT around the planet. The use of short-lived electronic appliances, which often consist of rare or hazardous materials and create additional energy requirements, can increase on pressure on the planet.

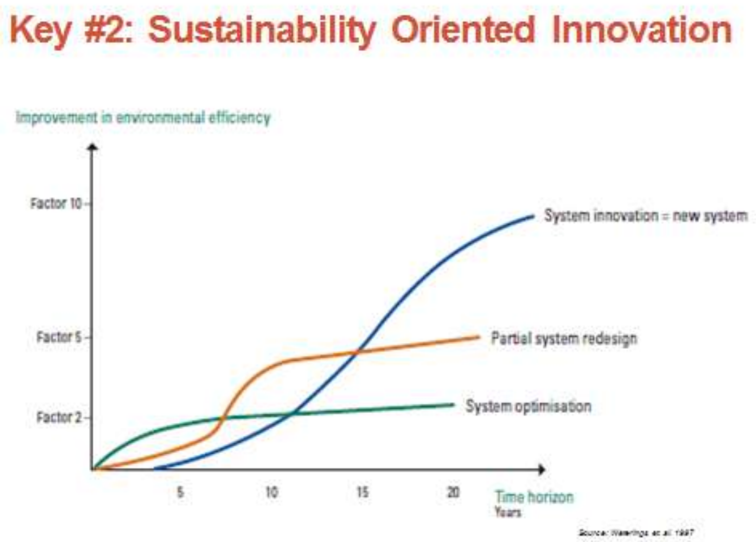
The pursuit of resource efficiency not only leads to high-tech but also to low-tech and affordable solutions for customers in emerging markets. More creative ways of approaching functionality, changed consumption behaviours and social innovation are essential to any systemic change.This could be a major opportunity for entrepreneurs in developing countries. These '***frugal innovations***' aim to bring products back to a level of basic simplicity and are designed to be inexpensive, robust and easy to use. Being frugal also means being sparse in the use of raw material and their impact on the environment. Although a relatively young concept, fugal innovation has been featured in popular media (The Economist 2010, The Financial Times 2012, and Time Magazine 2013) and could play a more important role in the future.



[47] EC 2009 and Bringezu 2009
[48] OECD 2010
[49] Bringezu 2009

A major bottleneck for the diffusion of green technologies and expertise is financing. Thus **finance** and finance structures are key to providing the means for investing in a sustainable transition. In Europe, an identifiable trend suggests that government support for clean technology equity financing is gaining importance[50]. New approaches urgently need to bring together technical and financial experts in order to develop and implement business models and innovative financing schemes. A key question for further research is how to finance innovations with long-term paybacks, when profits for the company are needed over the short term.

Structural and behavioural changes in how business and governments are run especially in *rich countries* are key to meeting future demands with limited resources. Currently businesses (especially large businesses) typically treat environmental issues as an externality and not as part of their core business. Integrating environmental sustainability in value creation and distribution leads to a restructuring of value chains and new types of producer-consumer relationships[51]. Similarly, the organization of public administration into ministries and agencies dealing with individual issues separately hinders coherence, cooperation and systemic solutions and may lead to opposing objectives (perverse subsidies). To overcome these institutional lock-ins, changes in the organisation of government may be necessary along with strong leadership and overarching targets. Lifestyle changes particularly in rich countries are needed to create demand for new and green innovations to pave way for the political willpower needed to instigate structural change. This includes changes in behaviour and introducing new forms of interactions between people. While people might be willing to make changes, they also need the tools to be able to implement those changes. Therefore, policies at the structural level are needed to provide infrastructure, means and information for people to be able to make more sustainable changes in their lifestyles.



A variety of studies have identified the transformation of today´s linear ‘take-make-dispose’ patterns towards a **circular economy** as one of the most promising strategies for a successful decoupling of resource consumption and economic growth[52]. Within the European Union about 2.7 billion tonnes of waste are generated annually, on average only 40% of the solid waste is re-used or recycled, the rest land-filled or incinerated. Yet, in some Member States more than 80% of waste is recycled, indicating the possibilities of securing the supply of raw materials while increasing resource efficiency. From a resource point of view the optimal approach is to prevent waste generation in the first place. The European Commission has obligated all member states to develop national waste prevention programmes that describe in detail how generation of waste can be decoupled from economic development.

[50] EIO 2012
[51] OECD 2012 and EIO 2013
[52] McKinsey 2011, EEA 2010, Ellen MacArthur Foundation 2013, UNEP 2013

The circular economy approach not only significantly decreases demand for natural resources, but also offers massive opportunities for new green business models. A report published by the Ellen MacArthur Foundation estimates an annual net material cost saving opportunity of up to 630 billion Euro at the EU level based on concrete and detailed product modelling: "*Economies will benefit from substantial net material savings, mitigation of volatility and supply risks, positive multipliers, potential employment benefits, reduced externalities, and long-term resilience of the economy*"[53].

5.3 Selected Indicative Examples

A few indicative examples demonstrate the potential and challenges for minimising the resource use of products.

Increasing the material efficiency of production processes is a low-hanging opportunity. If demand does not change, it is a win-win opportunity for companies (saving costs with low risk) and the environment (reducing resource demand). Germany has achieved a relatively high level of efficiency in manufacturing and actively promotes material efficiency in companies through the German Material Efficiency Agency (demea), which offers knowledge, skills (with more than 200 trained consultants) and funding (reimbursing costs up to 33%). Analysis of 100 case studies reveals that implementing material efficiency measures pays off within 13 months and saves Euro 200,000 on average. If all the companies in the manufacturing sector in Germany achieved these results, €13 billion could be saved annually[54]. The potentials are thought to be even higher for countries like India due to the large gap in efficiency of production practices. Nonetheless, for a country like Germany, these more incremental changes will not be enough to promote the kinds of structural changes needed for absolute resource decoupling over the long term.

Substitution can be an opportunity to reduce the resource use of products. For example, cars could be made of more aluminium than steel to reduce their weight in the future. It is estimated that a weight reduction of 100 kg lowers fuel consumption by 0.3 to 0.4 litres per 100 kilometres. However, the environmental performance of the product depends on more than just the emissions during its use phase. The aluminium versus steel debate depends on the recyclability of both materials, and the level of demand (e.g. a major shift to aluminium in automobiles would raise the demand for aluminium beyond even 100 % of the recycling potential).

It is also important to consider potential future scarcities and import dependencies. For instance, intensification in agriculture has traditionally relied on increasing inputs of fertilizers, pesticides and water. Phosphorous is especially important for meeting increasing demand for feed to supply meat and dairy products. Global phosphate reserves are expected to get exhausted in the next 80 to 120 years and the global market has already seen price shocks (between 2006 and 2008 the phosphorus price increased 10 fold). Projects to close the phosphorus loop through mono-incineration of sewage sludge reveal recovery rates of up to 90 %[55], but mass-market penetration is not expected before 2030 in Europe. This is indicative of an area where investments are needed today, in order to allow a smooth market transition to the conditions of tomorrow.

This type of anticipation requires enhanced knowledge and knowledge sharing on resource scarcity and is increasingly relevant as clean technologies may be hampered by resource scarcity in the future. In the case of the automobile, an indicative calculation for a third strategy to reduce the resource intensity of products by changing product structure illustrates this point. If all 2 billion cars assumed to be on the roads in 2050 were equipped with fuel cells, 6,000 tonnes of platinum would be needed, which is 30 times more than the mine production of 2008. If all of these cars were equipped with electric motors instead, 2

[53] Ellen MacArthur Foundation 2013, p. 66.
[54] EIO 2012
[55] E.g. SUSAN (http://www.susan.bam.de/); PASCH (http://www.phosphorrecycling.de/)

to 4 million tonnes of neodymium would be needed, which is about 100 to 200 times current annual mine production[56].

Thus, it should be carefully anticipated by in-depth scenario analyses whether an intended ambitious green structural change, like the introduction of renewables and energy efficiency, could cause an unintended problem, shifting and accelerating the criticality of strategic metals or the unsustainable use of biomass.[57] A strong argument in favour of absolute decoupling is the need to avoid burden shifting to other countries or future generations

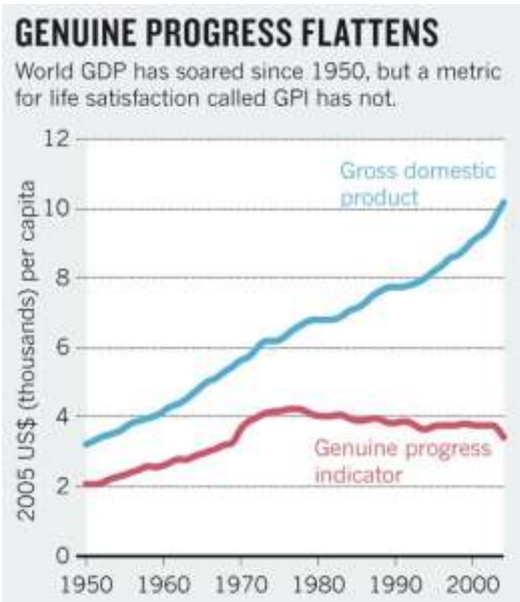
All of these examples reveal that there is no silver bullet solution for decoupling and that a wider systems perspective is needed to prevent problems of burden shifting among countries (e.g. exporting production abroad), balancing environmental pressures (e.g. reducing GHG emissions but raising toxicity) and over time (e.g. the rebound effect). For products, this requires asking questions about what the customer needs are and how they can be met in a profitable and less resource-intensive way. Such questions may lead to more radical changes in the design and delivery of products and services. For the automobile example it could lead to business models offering new mobility solutions like car sharing schemes.

6 OUTLOOK

There is much evidence in OECD countries that after a certain threshold rising GDP is decoupled from life satisfaction. For example, instead of growing in parallel with GDP, indicators of life satisfaction remain at a constant level up from the 1970s, as shown by the Genuine Progress Indicator[58] in Figure 5. This figure reveals that for 17 countries the GDP/capita and the GPI/capita developed in parallel from 1950 until about 1978, but then they decoupled dramatically[59].

Thus, it might be necessary to add a further important perspective to the decoupling agenda focussing much more than in the past on how much quality of life (life satisfaction) or happiness can be derived from GDP growth. This is by far not only a debate on the right metrics or on indicators, but it is a fundamental societal and political challenge especially for developed countries and for the urban of developing and emerging countries.

Figure 5: Genuine progress indicator versus GDP per capita



Source: Costanza et al. 2014 based on Kubiszewski et al. 2013

Thus, it is important to note that the logic of decoupling has significant implications for the understanding of growth. Based on a differentiation of physical and economic growth, there is a theoretical possibility of GDP growing indefinitely in a finite material world[60]. In this sense, the concept of decoupling also relates to macro-economic growth theories that define eco-innovations as a key driver of sustainable growth or theoretical concepts of sustainable transition management that aim to overcome existing resource intensive patterns of consumption and production[61].

The Environmental Kuznets Curve claims that if prosperity rises the environmental impact of

[56] Kleijn and van der Voet 2012

[57] ifeu et al, India´s Future Needs for Resources, Heidelberg August 2013
[58] Talberth et al. (2007)
[59] Costanza et al. 2014 based on Kubiszewski et al. 2013
[60] Ekins 2000
[61] e.g. Kemp/Pearson 2008

production and consumption increases in a first development phase, but then decreases beyond a certain point of prosperity and thus at least an impact decoupling will more or less automatically occur without any specific policy interventions. For the past this view might be based on empirical data. But in the future this development pattern is globally neither possible, nor necessary. Due to the threats e.g. of climate change, loss of biodiversity and resource depletion a world following past development patterns according to the Kuznets Curve will dramatically overrun the planetary boundaries.

On the other hand, due to tremendous technological and societal innovations developing and emerging countries can *leap frog* to much less resource intensive infrastructures, processes and products than in the past. Thus the Kuznets development phase- getting rich and dirty- must not happen at all or could be shortened, if failures of developed countries were avoided during the *take-off* phase of development. Thus the structural change of the sectors which contribute to macroeconomic growth will be tremendous and decoupling can be supported by a resource efficiency revolution.

It has been estimated[62] that the global share of middle class consumption[63] will rapidly grow in India and China between 2025 and 2050. According to these projections, in 2050 this share could rise for India to 31% and for China to 22%, leaving the EU, USA and Japan (together ca. 13 %) far behind. Thus the agenda of common, but differentiated patterns of consumption seems to be converging.

It might be especially useful to jointly identify technical, societal and structural leap frog options for sustainable production and consumption between developed and developing countries. The challenge for emerging economies like India is to find a way to circumvent the lock-jam highly capital intensive unsustainable infrastructure as an indicator of development have created. Not only are such installations, (for example in energy and water supply) locking more and more of capital, they are also preventing R&D or adaptation of smaller scale, eco-system based services options and especially circular economy approaches. New *"GreenTec"* and *"GreenSoc"* innovations like energy cooperatives, prosumers, smart grids, integrated city mobility, urban gardening or social enterprises, guilds and other artisan groups might be applicable in Germany and India. In addition, research based political consultancy is needed in time, because turning the juggernaut is a slow process.

For the time being *leaving GDP behind* is necessary, but due to data gaps, restrictions for international comparison and missing consensus it is still unavoidable to focus on decoupling concepts as defined above based on GDP and resource flow indicators. Nevertheless, challenging questions remain on

- What *'green'* growth means?
- What *'green'* sectors should grow rapidly?
- What *'brown'* sectors should be reduced?
- How much *'green'* growth is necessary at what development stage?
- What policies and measures are suitable to stop or even to invert the counterproductive decoupling of GDP growth and life satisfaction?

[62] Sea Kharas (2010) cited after EEA (2010).
[63] In this study „middle class" is defined as housholds with per capita daily spending between USD 10 and 100 purchasing power parity.

GOOD PRACTICE CASE STUDIES

Modelling and Implementing A Resource-Efficient Germany

FRAMING RESOURCE POLICIES IN GERMANY

In Germany as well as in other European countries there is an influential new debate in the research community and civil society on the topic of *Limits of Growth* or *"Post - Growth Society"*[64]. Though the debate started in the 1970s with Meadow`s Report to the Club of Rome, its revival is currently much more differentiated and policy oriented. Based on historical evidence of only **relative** decoupling in even the most resource efficient countries, some *anti-growth* advocates argue that in the future an **absolute** decoupling will not be possible. Climate and resource protection strategies will not work as long as efficiency gains are eaten up by growth. This thesis is mainly based on the assumption in a finite world by definition there cannot be infinite global economic growth, which is always connected with resource use.

The counterproductive impact of this simplified thesis is that it can be used as an argument against any ambitious efficiency strategies, be it on raising energy efficiency or at a broader scale on resource productivity. Thus it is necessary to analyse the thesis "No decoupling possible" for specific countries and using sophisticated modelling tools (e.g. dynamic Input-output-models).

With this background, Wuppertal Institute in cooperation with 30 partners from research and business conducted a comprehensive study on behalf of the Ministry of Environment on *"Material efficiency and resource consumption"* (MaRess)[65]. This project also contributed to pave the way to establish a governmental strategy: *"Program Resource Efficiency*"(ProgRess, see below).

The MaRess project started with the assumption that a tolerable level of resource and climate protection demands politics, business, and civil society take considerably more action than they have up until now, in order to limit the possible catastrophic developments. If this challenge generated a dedicated response, research should answer the question whether this response could be based on new opportunities to shape technical and social progress (*"nature saving – labour augmenting"*) in a manner which helps to conserve nature, create jobs, and is economically attractive at the same time. Under conditions of global competition one could even ask: Is there any alternative to forcing increased resource efficiency, because not taking advantage of the economic opportunities of resource efficiency means becoming a loser in the global structural change?

From a business perspective in Germany, material costs[66] generate over 45% of total costs (incl. approx. 2 % energy costs, in comparison to the share of total labour costs of ca. 20%) in the manufacturing industries. There is some evidence that in other developed and emerging economies the average share of material costs of processing industries is also very high[67]. For example for India the material and energy cost share for the same sector has been calculated at 71%[68].

To reduce this cost burden, "green technology" is one strategy to reduce material consumption (residues) and lower material costs at a national level and at the same time create opportunities for new business fields and jobs and thus increase competitiveness on global "lead markets". "Indian firms could realize huge monetary savings and decreased material costs if they would increase their resource efficiency capabilities and lower their use of materials. Taking the average 45% material cost share of German manufacturing companies as a very rough benchmark, Indian companies that produce resource-efficiently

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[64] See for example Seidl and Zahrnt (2010)
[65] See the project website at: http://ressourcen.wupperinst.org/en/home/index.html
[66] According to official statistics, material costs are defined as: „Raw materials and other preliminary products obtained from third parties, auxiliary and operating materials incl. third-party components, energy, water, fuels, office and advertising material, and non-activated low-value commodities (DESTA- TIS, FS 4, line 4.3., cost structures in producing trades). Therefore the material costs also include the advance services of upstream production stages. The stated cost fraction of 45% is based on the average production value of the processing industry.
[67] See for example IFEU et al. (2013)
[68] Government of India (2012) cited after IFEU et al. (2013)

could have the potential to save around Rs. 8,888 billion (514 billion US $) material costs..." [69]. Without any doubt the German manufacturing industry *"...does not operate at it´s resource efficiency frontier either"*[70].

The German consultancy company Roland Berger[71] identified six global "lead markets"on behalf of the German Ministry of Environment:

- Energy efficiency (39%),
- Sustainable water management (26%),
- Sustainable mobility (14%),
- Environmental friendly power (11%),
- Material efficiency (7%) and
- Waste management (3%).

The percentages (in brackets) are based on a total global potential of 1,400 EUR bn (2007) of the six "lead markets"with a probable rise to 3,100 EUR bn in 2020.

From a technological perspective these green "lead markets" are technological options to substitute "brown" technologies (e.g. fossil fuels), to reduce material and resource use and at the same time to mitigate climate change and foster sustainable development. Thus one important political focus of the MaRess project was to identify and recommend **integrated resource and climate protection strategies** for the German government.

Apparently there is a large amount of overlap between a climate protection strategy and a forced resource conservation strategy. This applies both to the shared portfolio of applied technologies and to the synergies of the implementation strategies. This increases the demands on an integrated and goal-oriented economic, environmental and research policy. A large incentive to implement this sort of integrated policy would be if a dedicated climate protection policy was amplified through the integration of resource conservation to create a win-win strategy for the economy.

MaRess modelling results on the combination of resource and climate protection policies show that for Germany even a limited use of resource policy tools already leads to positive acceleration of economic and environmental effects, if combined with an ambitious climate mitigation strategy. The MaRess simulation assumed a selected portfolio of resource policies, including e.g. the introduction of a primary buildings material tax, certain quota obligations to encourage the use of recycled materials, information (audits) and incentives to identify and implement cost effective material reduction potentials especially in SMEs. Based on these policy strategies the simulation calculations with the Panta Rhei model[72] for the year 2030 resulted in the following effects – respectively in comparison to a reference approach with active climate protection which ensures a reduction in greenhouse gases of 54% by 2030:

- a clear reduction in the absolute material consumption of around 20%
- an increase of the gross domestic product by around 14%
- an increase in employment levels of around 1.9% (under consideration of demographic factors and productivity-oriented wage developments) and
- a reduction of 251 billion Euro for the funding allocation in the federal budget by the year 2030.

Overall, the MaRess-calculation came to the conclusion that a consistent resource efficiency policy strengthens Germany's international competitive position if "industrial policy" drives "green" innovation. Thus this dynamic input/output-analysis demonstrated for the first time for a high technology country that "the combination of a dedicated climate protection policy and a policy to increase material efficiency can be used to achieve the absolute de-coupling of economic growth and resource consumption"[73]. This simulation result is also interesting because it can provide a new understanding of the balancing of the

[69] IFEU et al, op.cit. p. 43
[70] ibid
[71] BMU 2009
[72] B. Meyer, GWS/Uni Osnabrück
[73] Distelkamp et al. 2010

structural effects of “green“ growth industries and shrinking risk industries in the national economy. In addition, the development of more sustainable consumption and production patterns and the limiting of macro-economic “rebound“ and comfort effects can now be quantified and examined in more detail with modelling tools.

This is a new and promising field of international research on socio-economic transformation processes. On the one hand it could encourage an in-depth analysis of the possibility and necessary precondition of absolute decoupling. On the other hand, it strongly supports the integration of policies for climate, resource protection and sustainable development. Altogether, MaRess developed a comprehensive portfolio of a policy mix to raise resource productivity and at the same time support climate mitigation and economically benign strategies.

Selected policies and measures[74]

The numerous obstacles to efficient utilisation of resources, such as a lack of information, external costs, or path-dependencies demand a targeted framework as well as stimuli and incentives which promote increased resource efficiency. Therefore a sort of “toolbox“ was developed in MaRess for the government framework conditions, for the business sector, and for the consumers. Some policies and measures are selected below.

Framework conditions

Regulatory, fiscal, and contract-based tools can be used to trigger search processes as well as innovations, diffusion, and “green“ investments in resource efficiency technology.

Regulatory approaches:

- Reporting requirements for manufacturers and importers: A lack of information on the use of material is a key problem when it comes to resource policy. This problem is in particular a result of globalised supply chains and product life cycles. Manufacturers should be obligated to provide information on the material groups and materials used in their products. This tool provides the knowledge base for further incentive tools (e.g. production input regulations, labelling).
- Product input regulations can be used in order to influence the design and composition of products. Up to now, approaches in the area of resource conservation were primarily targeting the waste streams. Input regulations, however, apply to the product design phase. Requirements can also be tied to market access regulations.
- The EU Ecodesign Directive is suitable as the basis for regulatory approaches. It should be expanded to additional product groups and indicators which go beyond energy consumption.

Fiscal tools

- Taxation of primary building materials: The suggested amount is two Euro per ton, with the goal of increasing resource efficiency and reducing consumption.
- Differentiated VAT approaches can be used to reduce the tax burden on resource efficient products at the expense of inefficient products. One could also consider a tax advantage for secondary building materials or devices with contain a large percentage of recycled material.

International covenant

- An agreement based on private law between public agencies and stakeholders along the product life cycle can serve to close metal material cycles which cross international boundaries (e.g. vehicles). In this case one would define concrete goals to increase resource efficiency, for example by ensuring that recycling is performed in other countries.

Business level

*Financing-based incentives***:** The goal is to establish resource efficiency as a key factor for the power to compete in the financial sector – as a cost reduction approach and for the dynamic growth of green technology.

[74] See also the policy part of MaRess project (http://ressourcen.wupperinst.org/en/project/policies/index.html) as well as the summary in Hennicke and Schneidewind (2012).

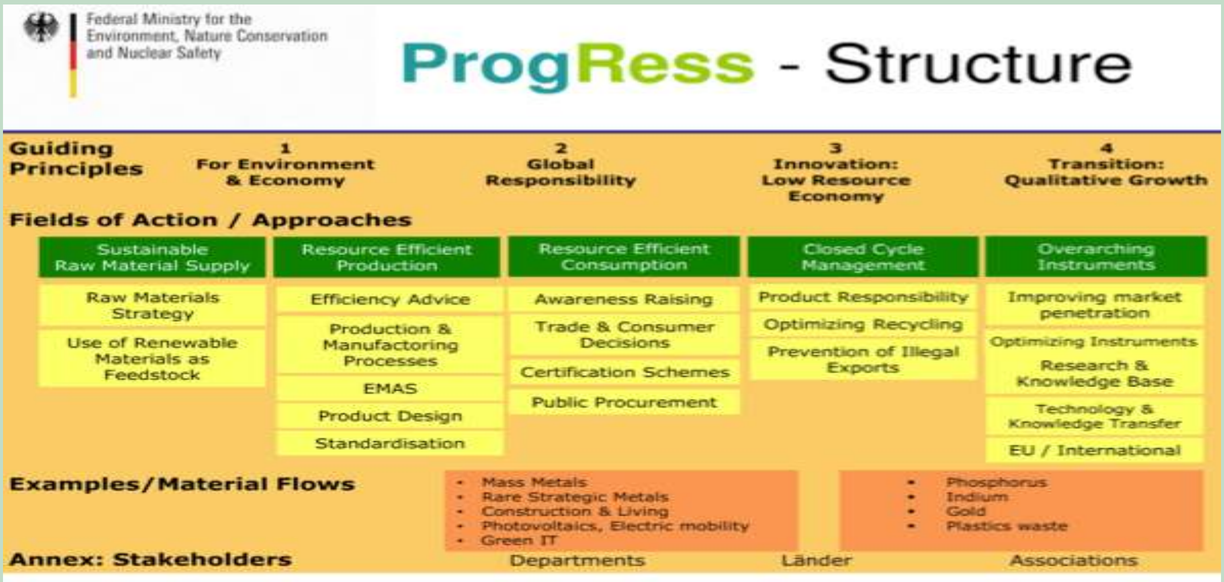
- Performance: Resource-based key performance indicators (R-KPI) allow the financial sector to apply resource efficiency criteria in everyday business, for financial supervision, and in company reporting.
- Dialogue: Establishing an inquiry commission "Resource Efficiency and Sustainability in the Financial Sector" in order to support the debate on the role of the financial sector in the protection of resources; development of a political strategy with all stakeholders.
- Research: Implementation of a federal research program worth ten million Euro could relate the financial sector perspectives with the well-founded results of environment and sustainability research, so that the results can be used functionally by politics and the financial sector.

Public Efficiency Awareness & Performance: Increasing the willingness to change behaviours and beneficial external offers and framework conditions.

- Supporting small and medium-sized enterprises (SME) locally: Expansion of the consultant pool and regional structures in order to improve understanding of the topic of resource efficiency and to communicate it locally.

The MaRess-Project was one cornerstone to develop a "German Programme Resource Efficiency (ProgRess). In 2012 the English edition of ProgRess was published[75]. Figure 4 summarises the complex structure of the planned ProgRess-Programme.

Figure 4: Structure of the German Resource Efficiency Programme



Source: A. Miehe, BMU 2011

For the first time in Europe, a comprehensive programme to foster resource efficiency was formulated. Mainly due to political priorities on implementing the ambitious German roadmap to a nuclear and (almost) fossil fuel free energy system up to 2050 ("Energiewende") the implementation of this programme has been postponed.

This paper argued that integration of the "Energiewende" (focussed on renewables and energy efficiency) with resource-/material efficiency policies would create a lot of macroeconomic benefits. Thus there might be an opportunity to develop an integrated energy and material efficiency programme to support the "Energiewende"

[75] BMU 2012

Good Practice Case Studies from India

There has been sporadic evidence of decoupling in the Indian context. The following three case studies highlight the approach followed and how they contribute to the core principles of decoupling.

Efficient water utilisation through participatory governance

Developing economies are particularly sensitive to surface water impacts of climate change and subsequent overuse of ground water because their economies and society are heavily dependent on agriculture. For e.g. ground water overdraft rate in northwest India is 56%[76].

Hiware Bazar in Maharashtra is a semi-arid village that from 1970s to 1990s ran out of most of its natural assets. The village faced an acute water crisis as a result of which during 1989-90, only 12% of the land was cultivated resulting in rampant poverty in the region. Like many other places in India, Hiware Bazar was in a classic overshoot and decline mode with the potential risk only becoming clear when wells ran dry. Water retention is limited due to poor permeability of the geological structures, and accentuated by degradation of forests and green cover over the years. The available water is poorly managed and access to water is determined by land and the capital to dig deeper and deeper wells. As a result large parts of the region are categorized as over-exploited, critical or semi-critical in terms of groundwater availability. Acute water shortages due to vegetation loss were undermining agricultural productivity.

Indicators	1991	2011
No of families	180	236
No of poor families	168	3
No. Landless Families	22	6
Annual Per Capita Income (INR)	832	30,000
Literacy (%)	30	95
Groundwater Availability (feet)	19-120	15-40
Area under irrigation (ha)	125	650
Area under summer irrigation (ha)	1-2	80
Cropping Intensity (%)	94	164
Fodder Availability (tonnes)	1500	6000

Source: Quarterly research Note, IDFC , June 2012

The village community however managed to turn the face of the village around in a matter of 5 years from 1995-2000. Agricultural production potential has increased by several orders of magnitude and contributed to reducing poverty by 73% in less than a decade[77]. An average villager earns almost double of most of India's rural population, with an average income increase of 20 times over creating 54 millionaires (Hiware Bazaar e-panchayat). Unlike other villages that desperately wait for government-supplied tanker water to meet their drinking needs, Hiware Bazar today has assured drinking water. The number of wells has increased from 97 to 217. Land under irrigation has increased from 120 Ha in 1999 to 260 Ha in 2006 (Hiware Bazaar e-Panchayat). They have also managed to plant a rabi crop, albeit over reduced acreage. Watershed development and strict observance of rules that preserve the water table have been central to this village's remarkable economic transformation[78].

A fundamental premise of the program was the adoption of participatory planning processes. It encouraged villagers to treat as a community resource, and empowered them to prioritize uses of available water. To institutionalise sharing of water, the village introduced a practice of water budgeting. Using 'water bank' principle, the budget ensures that the village does not draw more water than it stores in a year, and a small amount is kept in reserve. Depending on rainfall in that year, available water is allocated amongst various uses, with first priority for drinking water for humans at 50 litres per capita per day (lpcd)[79]. Of the remaining water, 70% is reserved for irrigation and 30% is stored for future use by allowing it to percolate and recharge groundwater[80].

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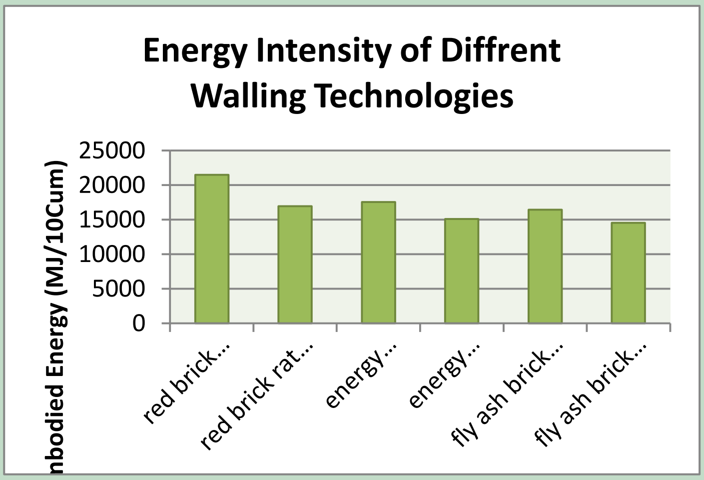
[76] Briscoe 2008
[77] TEEB 2012
[78] IDFC 2012
[79] ibid
[80] The Nature of Cities 2013

The irrigation was mainly carried out through energy and water efficient technologies of drip irrigation, open irrigation and with minimum use of ground water. Bhattarai et al. (2008) estimated that water efficient irrigation investment projects in India found economic multipliers of as much as three times. Such initiatives that deliver associated multiplier effects are a key part of the decoupling process.

Furthermore the village specially targeted ecological regeneration and also took advantage of the existing Employment Guarantee Scheme to regenerate degraded village forests and catchments and to restore watershed ecosystem. The villagers resorted to various watershed conservation techniques like contour trenching and bunding, tree plantation, rainwater harvesting, recharge of ground waters. The subsequent regeneration of degraded forests and building of earth embankments around hills have also helped to conserve rainwater and recharge groundwater.

Hiware Bazar imposed grazing restrictions on limited areas at a time viz. on a rotational basis, during reforestation. Bans were implemented in a staggered manner. For instance, a sudden and complete ban on open grazing would have an adverse impact on landless that rely on common pastures. After reforestation was complete, households could collect one head load of grass a day from common lands (cut by sickle to preserve the roots) for Rs. 100 per year[81]. This fee is waived for poor/landless families. Similarly, the tree-cutting ban was imposed incrementally beginning with forest land then moving to other areas. Babul trees were initially exempt to provide a source of firewood.

The success of Hiware Bazar rests on changing mindsets and participatory governance. It allowed the villagers to debate and prioritize their development goals, and manage their common resources such as water in an equitable and sustainable manner. Replication efforts for such large scale programs need convergence of development objectives, public and private funds and ardent involvement of multiple actors like government, beneficiaries and NGOs (as technical support). The keystone however is strong local leadership that creates the community drive and motivation.



CONSTRUCTING CHANGE WITH GREEN BUILDINGS

The scale of urban expansion in India is and will continue to be enormous, driven by economic and population growth. In 2011–2012, India's construction sector accounted for 8.2% of the country's GDP, employing 41 million people, and is poised to become the world's third-largest construction sector by 2018. Over the next ten years, the sector is expected to grow by 16-17%. The construction and use of buildings, driven by rapid urban expansion, is likely to impose tremendous pressures on the natural environment.

The construction sector has a large and growing resource footprint. It accounts for 30% of electricity consumption in India, growing at 8% a year and 23.6% of the national greenhouse gas (GHG) emissions[82]. Materials and equipment generally account for nearly two-thirds of total construction costs. Cement production is expected to increase from 228.3 Mt in 2010–2011 to 600 Mt by 2020. Despite a fall in the emission intensity of the cement industry, in 2007 it generated 129.9 Mt CO2. Some 200 billion bricks are produced each year, generating emissions of 41.6 Mt CO_2. It is estimated that 45% of India's steel output, 85% of paint, and 65%–70% of glass are used in the construction industry. The increased demand for

[81] IDFC 2012
[82] Parikh et al. 2009

materials and the consequent pressures on natural resources result in increasing material scarcity and escalating costs of construction.

According to the Bureau of Energy Efficiency, two-thirds of India's building stock that will be required by 2030 has yet to be built. Today's infrastructure investments will play a critical role in determining future resource intensity and affect India's ability to decouple resource consumption from economic growth. Urbanisation in India is less advanced than in many other countries, which presents an opportunity to avoid being locked into energy- and resource-intensive infrastructure. There is considerable potential for the further promotion of green buildings to reduce the environmental impact of construction and urbanisation in India.

The footprint of buildings certified by the Indian Green Building Council (IGBC) is currently over 1130 million m^2. The market for green buildings in India is projected to grow three-fold between 2011 and 2014, reaching $30 billion. With proven and commercially available technologies, energy consumption in new and existing buildings can be cut by an estimated 30% to 80%, with potential net profit during the building's lifespan[83]. Buildings compliant with India's Energy Conservation Building Code (ECBC) are estimated to be 20% to 30% more efficient than conventional buildings (Parikh, 2011). Besides energy efficiency, using recycled building materials saves between 12% and 40% of the total energy used during materials production, depending on the material[84]. Building design can maximise natural lighting and ventilation, which reduces energy needs and improves the quality of indoor air. These measures have a noticeable impact on the operating costs and result in savings over the building's lifetime.

The Development Alternatives Head Quarters in New Delhi is an example of how construction can be decoupled from resource use, such as energy, through material efficiency. Aiming at zero emissions, it is described as a living ecosystem: a fine balance between both natural and man-made processes using environment-friendly energy, resource and energy efficient building materials and water management methods for conservation of water. Its construction has involved a wide range of resource-saving strategies, ranging from the use of eco-materials and natural lighting to rainwater harvesting and water and material recycling. A key factor of success was the People Driven Design approach, wherein the design evolved over an interactive process between the DA staff and the architects and is sensitive to requirement of universal access. The building reaffirms a commitment to People and Nature.

It uses 30% less embodied energy through the highly efficient use of low energy natural materials based building elements like mud and fly ash blocks instead of burnt brick or concrete timber for doors and windows. 90% materials sourced from around Delhi; thus involving minimum transportation. The stone flooring pattern designed to reduce waste to less than 5%. 30% less steel and cement is used owing to the use of innovative technologies like Ferro-cement channels with minimal steel bars and chicken-wire mesh, Shallow domes with Fly Ash blocks requiring no steel reinforcement and Short-span reinforced cement concrete frame for basic structure

- 30% less cement and steel use through technologies like Ferrocement channels and Filler Slabs
- 20% less brick use through rat trap bonds
- 40% carbon saved through efficiently fired bricks
- Over 90% carbon saved through use of fly ash bricks

40% less operational energy is consumed via user acceptance of indoor temperature range from 180 to 280 Celsius. The orientation is optimised to maximise natural lighting and ventilation and minimise heat gain. "Green clothing" (planting on building façade), cavity walling and built-in shading devices minimise heat gain. An innovative "Hybrid" air conditioning system minimises use of energy and water prioritising evaporative cooling for hot and dry months and is supplemented by (CFC free) refrigerant cooling for hot and humid months.

[83] UNEP SBCI 2007
[84] ibid

The use of low-cost, local and low-embodied energy materials remains important for sustainable construction, and can support local economic development while also reducing environmental impacts[85]. In order to replicate and scale up such initiatives it is important to create an ecosystem where eco-friendly materials, technology and expertise are available and accessible to all.

Energy efficient transportation

Delhi ranked 3rd in a World Health Organization (WHO) survey of the most polluted cities in the country. Besides meteorological conditions contributing to the presence of natural dust, the transport sector is one of the major contributors towards the rising ambient air pollution levels and greenhouse gas emissions (13% of national emissions). Over the last three decades, Delhi has seen an unprecedented growth in the number of personalised vehicles. Delhi has more vehicles than Mumbai, Chennai and Kolkata with more than 90% of the vehicles being personal. The total number of vehicles registered in Delhi in 2011 is equal to the combined registrations done in Mumbai, Hyderabad and Chennai[86]. A recent trend observed, is that of the increasing consumption of both major auto fuels i.e. petrol and diesel. The contribution from the vehicular sector increased from 23% in the year 1970/71 to as much as 72% by the year 2001[87].

The government has undertaken many initiatives to introduce energy efficient transportation measures in the city. The main source of vehicular pollution is the fuel itself. Initially, policies were introduced by national and state governments based on vehicle and fuel efficiency, such as phasing out older vehicles and making compressed natural gas (CNG) a mandatory fuel in public transportation. In order to counter the increasing air pollution load and carbon emissions in Delhi, the Supreme Court passed the orders to move all the public transport on CNG by March 31, 2001. CNG (117 pounds of CO2 emitted per million Btu of energy) is less carbon intensive than petrol/ diesel based fuels (157 / 161 pounds of CO2 emitted per million Btu of energy), leading to fewer emissions for the same amount of fuel spent.

Some fiscal measures were put in operation for making conversion to CNG a financially feasible option for all stakeholders. Following the Court's order of April 5, 2005, for the first time in the country, penalty was imposed on the basis of polluter pays principle, on diesel buses for violating the Court order and not moving to CNG. This penalty has generated a huge corpus of Rs 30 crore that is today available to the Delhi government to fund other emissions control measures in the city[88]. Incentives like Sales-Tax exemption and interest subsidy on loans to the auto rickshaw owners also helped. This experiment demonstrates how it is possible to develop fiscal instruments for improvement of transport and technology to control emissions. This has been a pioneering effort and should build on to develop future fiscal policies in the city.

The co-ordinated measures for affecting the switchover were put in place by the Government of Delhi through multipronged action as different agencies were responsible for ensuring the environment friendliness of public transportation. The Government of Delhi explored all possibilities for using CNG, by holding discussions with vehicle manufacturers and other public transport agencies. Vehicle manufacturers were asked to bring CNG technology into the country. The Gas Authority of India Ltd. was requested to lay underground pipelines for setting up of new CNG stations. A phase out plan was put into place to ease the switchover.

A CPCB study shows that there has been a significant reduction in pollution at traffic intersections and in industrial areas in terms of CO, NO2, lead, SO2, and suspended particulate matter[89]. While there were around 1000 CNG vehicles in April 1998, by 2003, there were 70,249 vehicles including taxis, auto-rickshaws and 9000 buses plying exclusively on CNG. CNG is also the cheapest of auto-fuels, as per the

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[85] UN Habitat 2011
[86] Times of India 2012; http://articles.timesofindia.indiatimes.com/2012-11-26/india/35366083_1_vehicles-chennai-metro-bangalore
[87] DPCC n.d.
[88] CPCB 2003
[89] The Hindu--Delhi, "Marked Drop in Pollution Levels," 02/14/00

prevailing prices in May 2003, CNG compares favourably with diesel and petrol. However, use of clean fuels by the public transport system is only a part of the solution.

More recently, policies are focused on improving public transportation infrastructure, with the city's new metro as the flagship project. The first two phases were completed on 2006 and 2011 respectively, with Phase III and IV to be completed by 2021. Approximately, for 15 lakh passengers travelling in the Metro, 1.5 lakh vehicles are off the road[90]. It has also used flyash bricks in construction activity which, the corporation says, will save 3.9 million tonnes of carbon dioxide in 10 years (ibid).

It is the first metro rail and rail based system in the world that received carbon credits under the United Nations Framework Climate Change Convention Clean Development Mechanism. Under the regenerative braking process, whenever trains on the Metro network apply brakes, three phase-traction motors installed on these trains act as generators to produce electrical energy which goes back into the over head electricity (OHE) lines. The regenerated electrical energy supplied back to the OHE is used by other accelerating trains on the same service line, thus saving overall energy in the system as about 30% of electricity requirement is reduced[91]. It led to a prevention of nearly 90,000 tonnes of CO_2 from 2004 to 2007 with an additional 39,000 tonnes saved in 2008 (ibid). Every passenger who chooses to use Metro instead of car/bus contributes in reduction in emissions to the extent of approximately 100 gm of carbon-dioxide for every trip of 10 km and therefore, becomes party to the reduction in global warming (ibid). Over a two year period from 2008 to 2009, the Delhi Metro Rail Corporation earned nearly 4.8 crores INR through the sale of 1,64,000 certified emission reductions (CERs)[92]. The money earned through the sale of CERs is being used for stimulate research and development activities and to give training to train operators for optimum regeneration. Innovative technology has helped reduce energy and electricity consumption, thereby decoupling the public transport system from excessive resource use.

This success is now being replicated in other cities in India, extending to other modes of transportation. For e.g. Ahmedabad introduced the country's first Bus Rapid Transit System. More than 60,000 people switched from motorized two- and three- wheelers reducing 288,000 metric tons of CO_2 per year. Providing better and higher quality service is also preventing passengers from switching from buses to private cars and motorcycles even while their income rises.

[90] Times of India 2011, http://articles.timesofindia.indiatimes.com/2011-01-19/delhi/28363503_1_carbon-credits-carbon-trading-metro-trains
[91] Dehli Metro Rail Corporation (DMRC n.d.)
[92] Times of India 2011; http://articles.timesofindia.indiatimes.com/2011-04-13/delhi/29413468_1_carbon-credits-dmrc-delhi-metro-trains

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