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RESEARCH ARTICLE

Living The Future: Who Can Do What to Improve Human and Environmental Health While Securing Nutritious Food?

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ABSTRACT:
For the first time in human history, we encounter global limits of essential resources and are being challenged by the consequences of man-made climate change, reduced biodiversity and pollution by chemical substances. Feeding the extra 5.5 billion urban people in this century requires transformation of the present unsustainable agrifood system. Residents can take part in this transformation by changing to healthy diets, recycle food waste and come closer to the food markets, while public and private sectors could look for innovative ways to produce food and to design city infrastructure and buildings that will enhance recycling of limited resouces and reduce environmental foot prints.
Global data are forthcoming on resources and on causes of human and environmental ill heatlh, making it possible to conjure future resources restrictions and imbalances of nutrients. Today, the global agrifood system contributes more than a quarter of the global GHG emissions, four-fifth of eutrophication and more than nine-tenth of biodiversity losses. Revised diets, reduced food waste and soilless food production will significantly shrink agricultural land use – and proportionally reduce greenhouse gas emissions and biodiversity losses. Emerging infrastructure and technologies in combination with recycling of nutrients can close the resource gaps by halving the global demand for fertilisers and still feed the world.
Keywords: food security, dietary change, foot prints, nutrient recycling, greening cities, partnership in change

1. Introduction

Today´s discourse about Man and Nature deals with global environmental degradation such as climate change and biodiversity loss [1] and transgressing global resource boundaries. [2] All these issues are closely associated with our food systems that contribute one-third of the global emissions of greenhouse gases (GHG) [3] and even more to biodiversity losses. This indicates that people's food consumption and food waste and losses play a major role in the ongoing environmental degradation. The visibility factor is important in searching for solutions engaging people. It is not enough to condemn cutting down rainforests in Brazil and Indonesia, but we need to consider the full chain of events from customer demand for cheap palm oil to deforestation.

Gone are the days when Nature could accumulate all human discharges. Some 8 billion consumers do have profound and visible environmental impacts such as depletion of global resources and climate change. [1,2] Figure 1 illustrates the collective impact of individual household contributions to greenhouse gases. In daytime, the globe looks inviting with blue water covering 70% of its surface, but in night time the globe is lit by numerous cities. Together we achieve this by switching on lights in homes, streets, and vehicles. Each person contributes a small part, but jointly we add enough greenhouse gases to the thin layer of atmosphere which causes global warming and climate change. The lesson is that what takes place locally can affect the global environment and each person contributes to the degradation, but can also contribute to mitigation. Such situations occur also for many other resources than fossil-based energy. One example is individual family decisions on the number of children, which will add some extra 5 billion people on Earth in this century alone.

Figure 1. Satellite pictures of the globe in day- and night time. Source: Google.

Individuals can impact the global environment by e.g. changing diets and companies by searching for e.g. soilless sources of food. All of us are part of the problems as well as the solution connected to human and environmental health. This is the theme of this article.

2. Urbanisation and Food Security

Rapid population growth and unprecedented urbanisation in this century from 3 to an expected 8.5 billion people [4] create - in combination with industrialisation - unprecedented demands for water and food, and turn cities into hotspots for wastewater, sludge and other organic waste. Many cities lack proper wastewater treatment units or are slow in connecting homes to sewers and treatment plants, causing eutrophication of water bodies and emissions of greenhouse gases from organic sludge - and huge losses of nutrients that could be reused for food production. Also, climate change impacts such as global warming and erratic rainfall are causing water shortages, floods and food insecurity.

Figure 2 shows the growth and area distribution of the world's population over three centuries. The proportion of urban population was 5% in 1800, and is expected to reach 85% by the year 2100. Hence, global sustainability concern has turned from rural issues to environmental problems caused by consumption and disposal of waste in cities and to urban conservation, recovery and recycling of limited natural resources.

The figure allows for making various comparisons. A dot on a population curve may represent the volume of disposed urine in that year (red vertical lines) while the area between two years could for instance represent the total food eaten in that period (coloured areas). Assuming that urination and eating habits do not change, we observe that the total volume of urine has trebled between the years 1900 and 2000, and that the amount of eaten food is expected to increase by 80% in the second half of the 21st century compared to the first half.

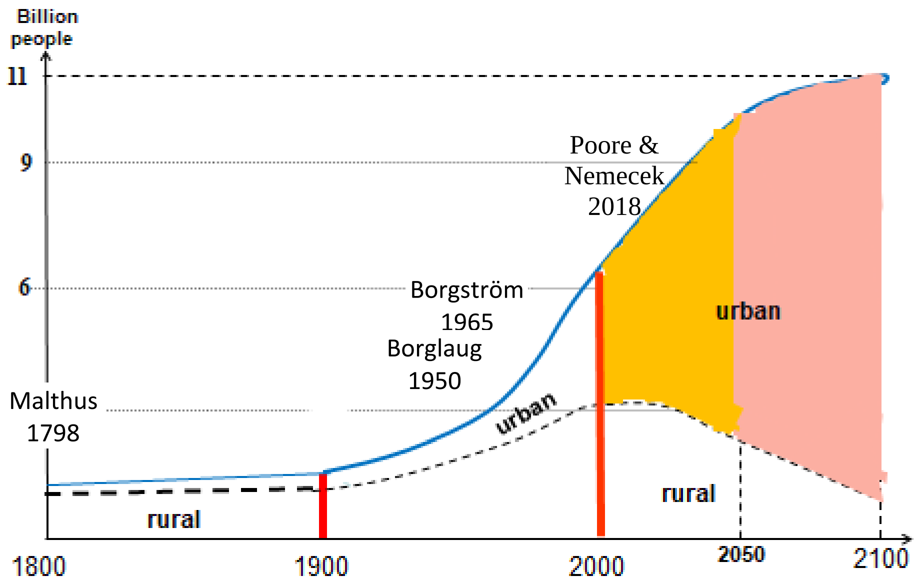

Figure 2. Development of the world's actual and expected urban and rural population from 1800 to 2100. The yellow- and pink-shaded areas can be used as a proxy of the volume of excreta, urine or food produced in the first and second halves of the present century respectively. Sources: [5].

Malthus (1798) worried about the discrepancy between a geometric population growth and an arithmetic increase in agricultural output that could only be fixed by recurring famine and death. [6] The food scientist George Borgström (1965) forwarded this line of thought after the Second World War, and pioneered the idea of reducing the resource-demanding production for animal-based diets in favour of plant-based diets.[7] This was also the time when Norman Borlaug's work set the Green Revolution in motion with three- and four-fold increases in yields through new high yielding, short-stemmed, rust-resistant wheat varieties, together with irrigation, pesticides and more fertilisers. The staple food winter wheat, for example, yielded only 2.7 t/ha in 1852-1871 and 3.07 t/ha in 1966/67, but with the Green Revolution yields increased to 5.48 t/ha in 1970-1975 and 8.69 t/ha in 1991/92. [8] Today, cereal yields differ by a factor of almost ten between wheat-producing countries. [9]

Malthus's fear of famine was warranted from his vantage point (Figure 2) with low productivity in the early 19th century, and high mortality rates. The Green Revolution has been successful ever since and provided enough but unequally distributed food produced on an only 11% larger area between 1960 and 2000. [10] But, substantial environmental costs have been associated with the increase in food production. [11] Today, half a century after the Green Revolution, worries are still with us but this time mainly associated with climate change, biodiversity losses and shortage of fertilisers - each of which would curtail agricultural output.

3. Aim of Study and Applied Methods

A global perspective drives the problem description, while both causes and remedies to human and environmental health degradation usually occur at local and regional levels. The growing concern about crossing planetary boundaries to access natural resources have identified nine global resources to be vulnerable to transgression of set boundaries. [2] The assumed boundaries have already been transgressed for three resources: biodiversity and the nitrogen and phosphorus cycles. [12] Next, global fresh water resources and potassium are imminent candidates. [13] All such estimates build on more or less certain data, and both exploitable resources and reserves may differ over time depending on technological advances, newly found deposits, or simple estimate errors. [14] More global data is forthcoming dealing with the relationship between food production and consumption and human and environment health. [1,11,15]

A systems-thinking is applied and daily routines among residents are viewed to be as important as resource-saving physical and management arrangements. Societal norms and individual perceptions influence the selection of sustainable measures. [15,16,17]

The guiding sustainability principle here is to reduce the negative impact of food consumption on the environment and to put nutrient flows from urban areas to use in food production, and then back to cities as food as described by the circular flow in Figure 3. Before urbanisation started in the mid-19th century, nutrient flows were circular but gradually went linear. [5] Present revival of circular flows is driven by transforming agents (red arrow) - often outside the agrifood system - and influencing for instance both diets and food production.

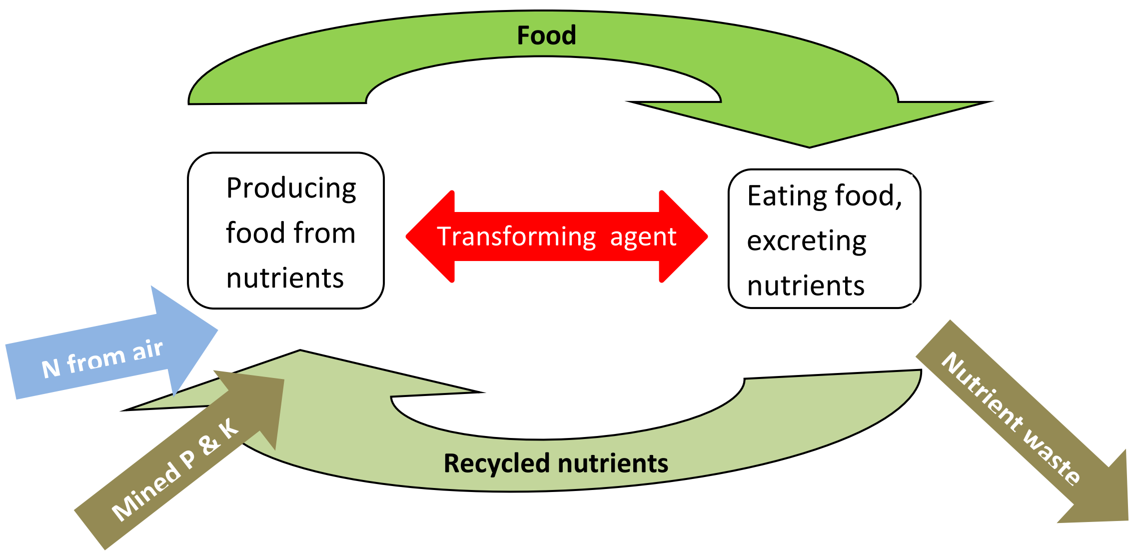

Figure 3. Nutrients flow between humans and plants and animals while waste and losses are substituted. Diets and food production are influenced by transforming agents (red arrow) often occurring outside the agrifood system.

The shifts of focus from local to global and back to local perspectives and partnerships is needed to address the present challenges of globally limited virgin resources to sustain our livelyhood and to limit our foot prints. Can cities with all their capabilities address such problems in a sustainable way? While housing and feeding the extra 5.5 billion urban people in this century, societies need to search for alternative production and consumption of food and innovative city infrastructure and house designs that support human and environmental health.

The production of food requires energy, water and nutrients, and in conventional agriculture these resources are drawn directly or indirectly from the sun, rainfall, land and partly mined mineral nutrients. The challenge is to nudge consumers and guide producers to jointly manage agrifood systems to avoid crossing planetary boundaries and to minimise human and environmental health risks.

4. Literature Fact Finding and Results

Food production and consumption have become unsustainable when required to feed 8 billion people, as evidenced by agrifood systems contributing one-third of total global GHG emissions. [1] Today, agriculture occupies half of the globe's habitable area, and food production negatively impacts at least five of the previously mentioned nine global environmental boundary issues (Figure 4). Agriculture emits 26% of the global greenhouse gases, uses 70% of the world's withdrawal of freshwater, contributes 78% of the globe's eutrophication of oceans and freshwater, and is responsible for 94% of the reduction of biodiversity biomass among mammals other than humans. [11] Food production and consumption - driven by present human demands – will contribute to irreversible environmental damage including climate change unless properly restructured in order to reduce environmental impacts such as global GHG emissions, eutrophication and biodiversity losses.

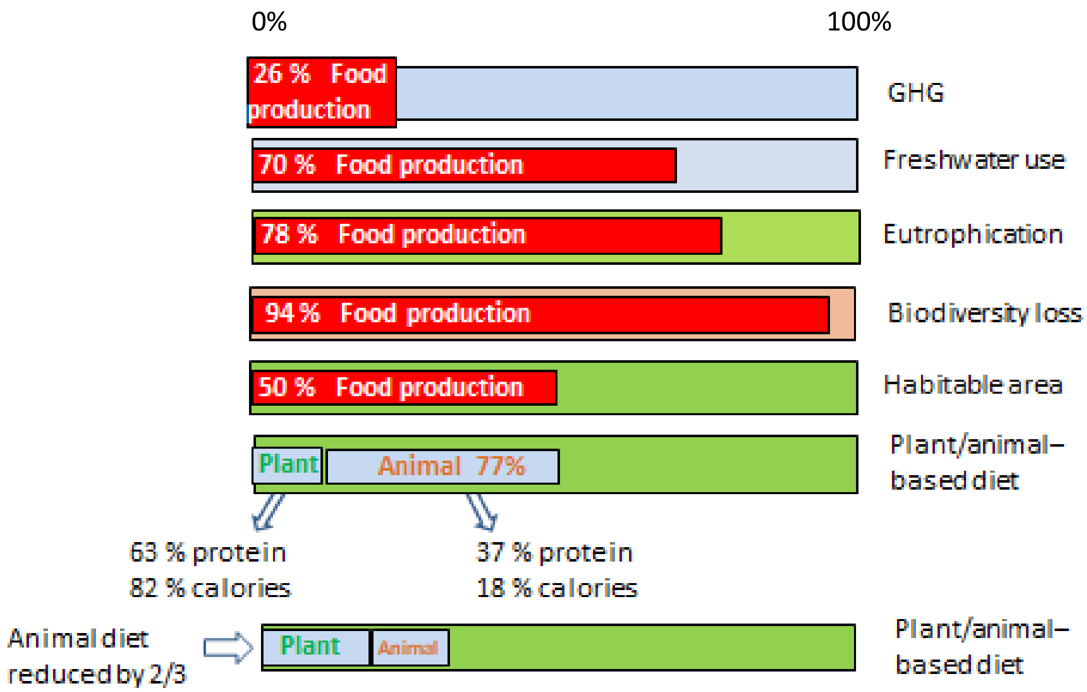

Figure 4. Impact of food production on environmental degradation, and the effects of a partial shift from animal to plant-based diets, while producing the same amounts of proteins and calories. Source: Created from data in [11].

In this section we present various ways to improve human and environmental health, and in the next section we discuss people's willingness to implement associated changes.

4.1 PEOPLE-CENTERED MEASURES TO PROTECT THE ENVIRONMENT AND HUMAN HEALTH

According to Poore and Nemecek 77% of the world's food producing area is used for animal production providing only 37% of the consumed proteins and 18% of the calories. [11] Calories and proteins indicate whether the food provides enough energy and cell-building material respectively. The remaining 23% of the producing area is for production of plant-based diets that provides 63% of the consumed proteins and 82% of the calories. The data can be used to estimate environmental effects when shifting to more plant-based diets, while compensating for the loss of calories and proteins by increasing the production of plant-based food as shown by the lowest bar of Figure 4.

4.1.1 Environmental effects of reduced animal-based diets

Initial crude calculations, which do not consider differences in soil fertility or that grazing and growing fodder often takes place on marginal land, tell us that with a zero animal-based diet, the same amount of eaten proteins and calories can be produced on a 60% and 70% smaller total agricultural area respectively. If people agree to a more realistic 2/3-rd cut of the animal-based diet, 42% and 48% smaller total area, including the required extension of the area for plant-based food production, is enough to produce the same amounts of protein resp. calories (lowest bar in Figure 4). This finding is in line with what, for instance, Helander et al. found for Germany - that dietary change could reduce cropland footprints by 43% for a Lancet reference diet and up to 48% for a vegetarian diet. [18]

Why do meat and dairy products require more nutrient input and emit more GHG than cereals and plant-based food? According to World Bank estimates, a kilogram of beef requires three times more grain and oilseeds than a kilogram of pork and five times more than chicken meat (cited in [19,20]). Soybean is a common ingredient in animal feed as well as plant-based food, and its protein content is about the same as in meat, some 15%, but beans need only one-tenth of the land area per produced kilogram compared to meat. [21] So, by consuming soybeans directly as an ingredient in a meal will reduce land use and environmental degradation proportionally compared to feeding soybeans to animals that are slaughtered and prepared as food.

The accompanied impact on the environment from reduced animal-based diets will be of about the same magnitude since the required reduced land area could be reclaimed by Nature. This also indicates that up to some 40% of GHG emissions and biodiversity losses from agriculture could be avoided. Further research is needed to document actual and potential effects of dietary change and its impact in different landscapes.

4.1.2 Environmental effects of reduced household food waste and losses

Reduced food waste and losses are identified as a major possibility to reduce acreage and the damage to the environment, and to save on fertilisers. The UN Sustainable Development Goal 12.3 aims to halve food waste and reduce food loss by 2030. UNEP reports that out of the food waste generated in 2019: 61% come from households, 26% from food service and 13% from retail. [22] Furthermore, levels of household food waste were found to be similar for high-income, upper middle-income and lower middle-income countries. A report by the Food and Agriculture Organization (FAO) estimated that around one third of food produced globally was lost or wasted, however, the authors acknowledged a lack of household food waste data outside of Europe and North America. [23] The report further suggests that such excessive wastage of food can be tackled by upstream measures such as improved household practices (especially in the North), and also food handling, packaging, transport, storage, etc.

Residents seem to have been rather unaware of the volume of food waste while being in favour of not wasting. Today, authorities and environmental groups – and even some food producers – propose hands-on guidelines for consumers to reduce food waste. [24] Eating more of the produced food will reduce land use and fertiliser input proportionally, and halving the waste would save some 16% (half of 1/3) of land and fertilisers. The produced but uneaten food is estimated to contribute 8% of global GHG emissions. [25] Meanwhile, reduced food waste means that less nutrients are available for recycling.

4.1.3 Transformation to more healthy food

Improved health is often thought to be a strong transforming agent of behavioral change. Four out of the top five human health risk factors are diet-related. [24] However, this does not translate to selecting more healthy diets as evidenced by the increased consumption of unhealthy food such as red meat and sugary products. [15] Red meat and emulsion additives are not addictive like tobacco and sugar, and should be prone to a reduction, but status or affordability or promotion may prove more decisive. A cautious impression is that authorities need to be more active in both nudging resident for dietary change toward healthy food and to support research and promote promising initiatives by raising taxes on unhealthy food. [26,27]

An innovative approach to gather and analyse household survey data on food composition and other changes is reported by FAO et al. and gives new insights into the interplay between drivers of change. [15] For example, the shift toward processed food was more widespread than expected in eleven middle-sized African towns, their peri-urban areas and even nearby villages. Animal-based food diets and food away from home increasingly substitute staple foods primarily in urban areas but also in peri-urban settings. The increases of such animal-based foods are driven by income, while increased consumption of fruits and vegetables is determined by access and availability. Similar results are reported by Li et al. on Chines rural and urban food consumption. [17]

The Food and Land Use Coalition argues that healthy diets are generally more resource efficient as for the needed amount of land and water compared to foods widely found in less healthy diets and, therefore, a transition to healthier diets also generates climate and biodiversity gains. [28]

According to Springmann et al. a change of diet from meat to beans and pulses and more fruits and vegetables would improve health. [29] They found that about half of the global deaths could be avoided thanks to eating 56% less red meat and the other half thanks to a combination of eating 25% more fruit and vegetables while reducing consumption of calories by 15% (with associated decreases in the fraction of overweight and obese people). These global averages comprise major regional differences. In the UK, the National Food Strategy found that 80% of the processed food is cheap but unhealthy and, together with the growing calorie-rich junk-food diets causing obesity, represent big health risks. [24]

4.1.4 Transformation to more soilless food production

A recent promising innovation is to use algae as an ingredient in food and feed. The protein content of algae is high, about 40%, and requires 87% less area than soybeans and 99% less water. [30] Another alternative method to make meat production more independent of fertilisers and available land is to let earthworms or fly larvae process manure and organic waste into protein-rich animal feed. [31] This resonates with the FAO aim to increase insect-based food production in order to feed the growing global population. [32] However, both algae and soybeans need a considerable input of (fertiliser) nutrients and energy to deliver good yields. More research is needed to make algae, worms and flies competitive on a large scale.

A more futuristic approach is to make e.g. fat and oil molecules from CO_2 in an energy-demanding chemical process. [33] Oil from palm tree plantations could be replaced by industrially produced molecules which are identical to the ones produced by nature. Oil crops make up 12% of global crop production [9] and could ideally be made soilless and without fertilisers. Another development run by NASA is to convert electric energy, air, and water into simple molecules that can be used as sources of energy to turn the carbon, nitrogen, hydrogen and oxygen from air and water into more microbes that produce food molecules – including proteins, fats, carbohydrates, and dietary fiber – in the form of safe, palatable foodstuffs with various flavors and textures. [34]

Plant-based alternatives have only a fraction of a percent of the meat market today. The present experience is that pioneering companies producing alternative products face falling financial valuation and market expectations. [35] However, the Food and Land Use Coalition anticipates that soilless food production alone could account for as much as 10% of the global protein market by 2030 and then scale rapidly. [28]

4.2 COMMUNITY-ORIENTED TRANSFORMATION OF INFRASTRUCTURE AND OTHER ARRANGEMENTS

Public institutions and industry can facilitate community and individual actions to secure human and environmental health and to access healthy food. In the following we address some measures that could be considered, such as infrastructure and house design, urban planning, urban agriculture and restricted use of chemical substances.

4.2.1 An awareness shift from pathogens to chemical substances

A sanitation arrangement must be easy to use, but difficult to abuse. Modern piped systems, however, make material flows invisible and thereby easy to abuse. [36] Toxic or harmful fluids and solids in various products are not seen with the naked eye, and therefore residents may dispose of such items in the toilet, washbasin, sink and rubbish bin. Also, the municipal sewerage is concealed in the ground and after passing a treatment plant the effluent is disposed of in a water body while the polluted sludge is likely to be landfilled or incinerated. [37] Poor sections of cities still struggle with filth and unhygienic conditions, and disease-causing pathogens remain a serious concern. [16] However, increasing health risks affecting all citizens originate from purchases of products containing harmful man-made chemical substances. [38,39] Wastewater treatment plants are unable to treat/remove most of such substances in the sludge or effluent – only stricter regulations can solve this problem by restricting industries from using a number of harmful chemical substances. [40] This is an example of the necessary shift of environmental awareness to upstream actions - from cure over to prevention - while accepting that the two are intrinsically intertwined. [41,42]

4.2.2 Recycling urban-derived nutrients to secure food production

Productive soils contain macro- and micronutrients that plants need, and by adding mineral fertiliser we can increase yields as shown by the Green Revolution. Since humans essentially capture the energy in the eaten food, almost all nutrients leave the body unchanged. Excreta and food waste contain most of the vast amounts of valuable nutrients and organic matter leaving communities, so called urban-derived nutrients. [43] These nutrients are needed in food production and cities can decide to recycle them as fertilisers or let them contribute to eutrophication of water bodies and other emissions. If this nutrient flow is not mixed with ordinary wastewater from households and industry, the flow will contain few harmful substances, mainly pharmaceutical residues that soil microorganisms are likely to break down. [44] Recycling treated nutrient-rich wastes back to fields and food production – becomes an ultimate sink and resource. [45]

Studies show that N, P and K in urban-derived nutrients have the potential to replace 20%, 35% and 46% respectively of the applied mineral fertilisers in Sweden. [46] This is possible if the toilet water is not mixed with contaminated wastewater from showers and handwash basins. Also, an easy-to-collect system has to be in place. Urban mining of nutrients can therefore be one way to avoid transgressing global boundaries. Such shifts require a different mindset and new solutions, often involving several sectors and methods to mitigate present-day challenges. [47]

Up to the turn of the century year 1900 urban agriculture and animal husbandry were common in European towns and long after on other continents. [48] There are signs of a revival of urban agriculture but this time for health reasons rather than food security. Urban and peri-urban agriculture

(UPA) has the potential to increase the availability of fruits and vegetables for urban dwellers. [49] One of their findings was that there is enough space to produce all fruit and vegetable requirement within city limits in the UK. Rooftop cultivation is becoming popular for example in Singapore and New York. [45,50] The total planted balcony area of two 27-storey buildings in Milan, Italy, called the Vertical Forest, correspond to 20 000 m^2 or 2 ha of forest land, while the base area of the buildings is only 1 500 m^2. [51]

4.2.3 Housing and infrastructure

Planners, architects and decision-makers decide the city infrastructure and they are therefore pivotal for improving urban sustainability. They have access to many options and tools to enable other actors to recycle flows of water and nutrients in our cities.

An estimated 8.5 billion will live in cities at the end of the century, and over 90% of this increase will occur in low-income countries, especially in Africa and parts of Asia. This means that, on average, twice the number of dwellings and offices that existed in 2000 will be erected during this century. Thus, there is now a unique opportunity to set aside green areas and equip all new buildings with green sanitation systems. The result is that two-thirds of all buildings will be water- and nutrient-effective by the end of this century, without any extra cost for retrofitting. Existing buildings will be retrofitted during this century in any case and can be made water- and nutrient-smart at low cost, while relying on suitable city infrastructure to be installed.

House design and decentralized city infrastructure play a crucial role in grasping the opportunities that urbanisation offers to ameliorate urban sustainability problems. Societies could also avoid negative path dependency by adopting as flexible solutions as possible. Cities in the past expanded horizontally in the North often with villa suburbs and small central districts, while much more rapidly growing suburbs in the South expand vertically and are dominated by tall residential buildings. None of these arrangements turned out to be conducive to recycling. Common, though, is that the streets and parking places for private cars have been prioritised at the expense of other means of transport as well as of green areas. [52]

Such historical facts will restrict the range of designs of e.g. sustainable water and nutrient flows in existing cities. A shift in priorities that factors in sustainable water, sanitation and transit requirements at the expense of space-demanding cars is easier today when urban transport is diversifying with the return of (electric) two-wheelers and improved public transport while green areas make walking and biking more attractive.

Figure 5 shows that space for greening purposes could also be made available in existing urban areas. Green flat roofs may be used to catch and retard rain for conservation and for food production. Parts of streets and parking lots will be available as transit is transformed. Work from home, digital meetings and other changes in life style can further reduce the space needed for transport. In turn, this shift in urban land use will also save natural resources and reduce pollution by design. [37]

Figure 5. Greening of roofs and freed city space. An example of changed urban infrastructure, here to increase urban green areas by reducing car traffic. Roadway required by the same 80 passengers traveling by car, bicycle, or bus. Source: Adapted from [53].

For long, material flows through pipes has reduced recycling of water and nutrients, and only in this century has recycling again gained importance. [5] Experience shows that costly innovations are possible, such as to introduce separate pipes for wastewater and stormwater (to reduce overflow at treatment plants), and pre-treatment of wastewater from individual industries before connecting to the communal wastewater grid. Similarily, it would be possible to keep toilet water separate from harmful greywater – at least in new residential areas – in order to secure the high-quality nutrient-rich flow for making fertilisers of its sludge. [45]

With water scarcity looming large, the regulatory agencies in India have started taking a pro-active role in treating wastewater on site i.e. in the basement, especially in large apartment complexes and large commercial buildings. [54] More and more buildings are adapting to this change and use the treated water for non-potable purposes. With regulatory agency imposing use of wastewater for construction related activities, markets for wastewater are emerging.

5. Discussion

Today, cities cover less than 1% of the globe´s habitable area, while agriculture occupies half. Big transformations in the agrifood sectors go on with little public guidance and are often informed or mediated by changes in other sectors of society. One such example is the shift to purchase prepared food. The expansion of agriculture has been driven by population increase, and the urban population in the world will almost tripple in this century. Today, about one-third of the global population is residing in intermediate and small cities and towns and is well connected to their rural hinterland. There is even a movement where farmers stay with their families in town, and commute to their farms (e.g. Canada and India). All this calls for a change of direction in policy which considers both agrifood systems and spatial dynamics, and their interactions and interconnectedness could facilitate access to healthy food. [15]

The growing importance of food purchases, and of processed foods in dietary patterns, opens up the opportunity for agrifood systems activities which link primary production to the final consumer. High value vegetable production is the last to disappear and be relocated outside the city, when urbanisation takes hold on a city district. At the same time, however, there is a push for small-scale urban and peri-urban agriculture on roof tops, balconies and growing walls, often motivated by hygiene and health reasons. Of late, some food supermarkets produce soilless vegetables inside the shop in advanced greenhouses using electric light and nutritious irrigation water. Another way to move food production back to urban areas is to produce soilless food in factories. If such developments are moderately successful, rainfed agriculture and animal husbandry as we know them will shrink and remain in the rural hinterland.

The increased interconnectedness driven by urbanisation facilitates the creation of scale economies for smallholder farmers and agrifood small and medium enterprises (SMEs), increase off-farm employment opportunities and rural household incomes, and may reduce the cost of healthy diets. [15]

Since a plant-based diet requires less land, water and fertilisers than animal-based diets, the pressure on resources is reduced and so is the associated environmental degradation. In combination with reduced food waste and losses, humans can produce enough (healthy) food on a smaller area than today, and Nature can reclaim land. This, in turn, reduces GHG emissions, biodiversity losses and water eutrophication substantially. Thereby, the certain disaster otherwise caused by conventional agriculture and reduced yields towards the end of the century can be avoided.

For the first time in human history do we face man-made climate change and global limition of physical resources. However, nutrient resources cannot only be extracted from virgin sources, but are also available along the life cycle of each resource flow. Such recycling can replace substantial amounts of mined P and K as well as manufactured N in mineral fertilisers, and in addition provide badly needed organic material to poor soils. By redesigning sewer systems in buildings and streets, valuable nutrients can be easily recovered and recycled to agriculture. Keeping toilet water in a separate pipe will in addition provide a toxic-free fertiliser without first reducing harmful chemical substances in mixed wastewater. In the long run chemical industry and authorities also need to phase out harmful as well as non-degradable products and replace these with available alternatives. In this way, grey wastewater effluent and sludge become feasible to recycle.

Recycling societies need to rebalance responsibilities between householders and various service providers, as to who can or will do what. United Nation with its 193 member states responded to the above challenges by declaring that provision of water and, from 2022, basic sanitation are human rights. The likely understanding is that public or private utilities must provide such services, since there is no mentioning of users as partners in these tasks. The consequence is that residents, who are the ones using the supplied water and disposing various wastes after use, tend to sense little or no responsibility for resource-smart uses or to avoid polluting water while using it, since the authorities are also responsible for sanitation including the treatment of solid waste and wastewater. While waiting for proper support users will either suffer or take on the responsibility themselves. If so, governments will find it more difficult to nudge residents to contribute by saving resources and refrain from harmful disposals.

The operators of any infrastucture cannot manage everything, however, and supportive residents can do more than paying service bills. Already, utilities need to treat users as customers in order to make them accept power and water cuts and higher tariffs. With increasing volumes and complexity of consumer goods, utilities also need users to become partners who engage in being mindful of what to purchase and dispose of and how. This new user role requires trust and that has to be gained over long periods of time and be supported by trustworthy exchange of information. However, this partnership engagement must not require unnecessary user duties. There is room for trials of various partnership models.

6. Conclusion

The food production and consumption has become less sustainable over time due to high demand caused by rapid population growth and escalating urbanisation. Today, the agrifood system contributes more than a quarter of the global GHG emissions, four-fifth of eutrophication and more than nine-tenth of biodiversity losses.

Revised diets and food production together with reduced food wastage and more reuse and recycling of urban-derived nutrients, can assist humanity to secure a healthy food supply, to let Nature reclaim land and to reduce environmental burdens significantly already in this century.

Such results can be achieved by cities, industry and residents working as partners in managing food production and consumption as well as nutrient resource flows. Present focus on reducing fossil energy and electrifying transportation must be accompanied by the above agrifood-related measures in order to quickly reach acceptable and sustainable levels of human and environmental health.

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