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The Environmental Resources Embodied in Food Waste

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Over 70% of all abstracted freshwater is used for food production mainly for crop irrigation and the agriculture industry contributes 32.1% of global CO_2Eq, but only 3.8% of global GDP. Population growth has had an inevitable impact on global agricultural food production, for example, the world population was approximately 2.5 billion in 1950 and has increased to 7.6 billion in 2018. The volume of water used by agriculture has also markedly increased over this period, from approximately 1000 $km^3\ y^{-1}$ in 1950 to a current rate of 2700 $km^3\ y^{-1}$, largely driven by population growth and the demand for food, but also through economic development leading to greater consumer demand for more exotic and resource intensive foods including meat and dairy products. For example, 1 kg of grain requires 1,600 L of water, whereas 1 kg of meat requires 5,000 - 20,000 L of water and 120 L of water are consumed to produce a glass of wine.

Modern agricultural practices have been established for around 100 years, for instance the first industrial production of ammonia began in 1913; the global consumption of NPK fertilizers for food production is now in the region of 145Mt. The modern agricultural industry has been highly successful in meeting the increased demand for food and supplies consumers in industrialised countries with a plentiful supply and diverse range of inexpensive food. This has been possible through the increased intensification of animal and crop production systems with greater inputs of agrochemicals and irrigation. In conventional modern systems these inputs to field crops are supplied following an inundation strategy so that all areas receive the same dose, irrespective of whether the pesticide, fertiliser or irrigation input is required or not. Consequently, some areas of a field may be potentially over supplied leading to the potential wastage and emissions of agrochemicals to the environment. The increased intensification and general inundation approach to agricultural production has led to significant unintended consequences in terms of environmental emissions. Thus, agricultural leaching of nitrate fertilisers has significantly impacted the quality of groundwater resources for potable supply, and pesticide and nutrient emissions to surface waters contribute to the overall decline observed in the biodiversity of fresh water species, which is greater than in either terrestrial or marine environments. Therefore, there are significant indirect environmental costs of modern intensive agricultural practices, relating to pollution, natural capital degradation and biodiversity loss, representing approximately 40% of food production costs.

Agricultural water use is expected to increase by a further 20% globally, but there will also be greater competition for water from other sectors including industrial and municipal use in the future. Given these impacts and the resource implications, agriculture must adapt to these rapidly changing conditions and increase efficiency, produce more food to meet the overall global demand, but with reduced inputs and less waste and move towards more sustainable production systems. The Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada convened by the Council of Canadian Academies concluded in its report on Water and Agriculture in Canada: Towards Sustainable Management of Water Resources concluded that this can be achieved by implementing combinations of strategies and technologies and that a broad research remit across the technology spectrum would be necessary to deliver these positive outcomes. Two keys areas identified of specific interest and a research priority were precision agriculture and the associated variable rate application systems to enable smarter targeting of resource inputs compared to the standard general inundation approach that is common practice in agricultural systems.

Agricultural production systems must change to become more efficient and reduce the environmental impact and costs. However, wider society also has a responsibility in valuing the importance of food and the major resource demands to produce it. Some estimates suggest global food wastage may be as high as 50% of production, and in some regions, such as north America almost 50% of food that is produced is wasted. We developed a global food waste model to estimate the amounts of resources embodied in edible food waste, based on regional food production, diets and waste generation patterns. This suggested that globally, 21% of agricultural food production is wasted, equivalent to 1,243Mt of food and:

(1) an embodied CO_2Eq Footprint of 2,567 tCO_2Eq which is 6.8% of global CO_2Eq
(2) an embodied Water Footprint of 390.1 trillion L which is 14.8% of global water use
(3) a value of $582.8bn, which is 0.8% of global GDP

Food waste is mainly disposed by landfilling and is therefore a major source of methane, a potent greenhouse gas, thus contributing significantly to climate change processes.

Rational environmental management policies must consider food waste; conserving the resources in food that is wasted would significantly offset global water stress and the environmental impacts of intensive agricultural production. Pricing food realistically to reflect the total environmental and other costs would help to increase the value and importance society places on food to reduce wasting water and other resources embodied in food waste. Better matching of agricultural production with market demand would also help to avoid producing unwanted food and wasting embodied resources.