An ecological footprint for an early learning centre: identifying opportunities for early childhood sustainability education through interdisciplinary research

Introduction and background

Current rates of resource consumption by the global human population are unsustainable (Haberl, Wackernagel & Wrbka, 2004; Kitzes, Peller, Goldfinger & Wackernagel, 2007; Rees, 1996). Our current usage of land to provide goods and services is beyond that which can be sustained by the planet, i.e. we are depleting "natural capital", the ability of nature to provide essential ecosystem services, such as those which support food production and maintain water quality (Gough, 2005; Rees, 1996; Vitousek, Mooney, Lubchenco & Melillo, 1997).

Sustainability indicators play an important role in tackling this problem through quantifying the effects of consumption, determining those activities that have the greatest impacts, highlighting where mitigation measures should best be applied, and conveying complex sustainability concepts to the public (Haberl et al. 2004; Mitchell, 1996; Rees 1996). The ecological footprint is a sustainability indicator which quantifies how much regenerative biological capacity is being consumed by human activity, and thus can pinpoint where consumption exceeds environmental limits nationally and globally (Lenzen & Murray, 2001; Kitzes & Wackernagel 2009; Wackernagel and Rees, 1995). For example, global ecological footprint accounting in 2003 found that current use of land by the human population exceeded the earth's biocapacity by 25 % (Kiztes et al. 2007).

Thus substantial changes are required to current thinking and practices in all sectors of society to ensure "intergenerational equity", that is, that future generations have access to at least an equivalent quality of life as today's generations. This has important implications for children and early childhood education. Firstly, young children have the most to lose from unsustainable practices with, for example, water and energy shortages, biodiversity loss and food security having the potential to disrupt both their current and future options (Davis, 2010). Secondly, education across the lifespan has an important contributory role in guiding the changes required to reduce consumption to sustainable levels. As Rickinson, Lundholm & Hopwood (2009) comment, a life-course perspective on education and learning is needed "to think about what we know and what we need to know about environmental learning during infancy, childhood, adolescence, adulthood, middle age, retirement and old age" (p. 106). This paper focuses on the first stages of the human life-course. It proposes how ecological footprinting may be used to leverage change in consumption practices within early childhood education settings, and contribute to early environmental learning.

In addition to assessing global consumption, the ecological footprint method can be applied on smaller scales to assist individuals and institutions to make connections between their day-to-day actions and associated impacts, to pinpoint the sources of their greatest environmental impacts, to move to more sustainable practices, and to adopt more effective mitigation and education measures (Barrett, Birch, Cherrett & Simmons, 2004; Chesterman, 2008; Cordero et al, 2008; Flint, 2001). A footprint may be calculated for a given area or system – such as a home, school, kindergarten or early childhood centre - by considering the goods consumed and wastes produced within its boundaries, then determining how much land is utilised to produce the goods and absorb the wastes. Ecological footprints are commonly calculated over a yearly basis. For the purposes of the ecological footprint calculation, land is categorised as (Kitzes et al. 2007):

1. Bioproductive land: land and sea that produces goods and services through biological processes which may be further categorised into cropland, pasture, fishing ground and forest
2. Built-up land: land upon which structures are constructed
3. Carbon/energy land: land required to absorb greenhouse gas emissions generated from fossil fuel combustion, agriculture etc.

Education institutions such as universities, schools and early childhood centres provide an effective way to widely publicise and educate the community with concepts of sustainability and environmental responsibility, through student learning and via their larger societal connections (Chesterman, 2008; Cortese, 2003; Moles, Carragher, & O'Regan, 2008; Wright & Drossman, 2002). As the ecological footprint has proven educative value (Cordero, Todd & Abellera, 2008), it makes sense to apply it directly to the activities of education institutions. Ecological footprints have been quantified and investigated for a number of universities and schools (Conway, Dalton, Loo & Benakoun, 2008; Flint, 2001; Lenzen & Murray, 2001; Moles et al, 2008; Sawchuck & Cameron, 2000; Venetoulis, 2001; Wang, Li, Gu, Liu, Ding & Liang, 2008).

A large gap in sustainability education exists at the early childhood level (Davis, 2009; Wals, 2009), however. The use of the ecological footprint has not been established in this sector though the easily communicated nature of the ecological footprint suggests that it may be an effective mechanism for assisting young children's learning about and actions for sustainability, as well as within their wider communities. This study provides a concrete example of an ecological footprint for an early childhood learning centre. Its development involved an interdisciplinary collaboration between engineers and early childhood educators. The results were analysed to determine how environmental impacts can be reduced at the study site itself as well as indicating potential reductions more generally across the early childhood education sector. In particular, we have provided suggestions for how this information might be understood by young children.

Scope and objectives of the study

The study site

Campus Kindergarten (CK) is located on the grounds of the University of Queensland's St Lucia Campus (Brisbane, Australia). At the time of the study, 20 staff were employed at CK over 48 weeks of the year. The centre operates from 8 am to 5:30 pm, with 73-76 children aged between 2 ½ and 5 ½ years attending daily. For the past 10 years, CK has been implementing its 'Sustainable Planet Project' where efforts have been made to decrease the environmental impact of the kindergarten and to promote learning for sustainability (see Davis, Rowntree, Gibson, Pratt & Eglington, 2005). Despite this long-running initiative, the kindergarten community has no quantitative measure of their environmental impacts.

Objectives of the study

The specific objectives of the study were to:

- Quantify the environmental impact of Campus Kindergarten by calculating its ecological footprint;
- Identify the key contributors to the overall ecological footprint of Campus Kindergarten, and assess how the kindergarten might reduce these impacts;
- Use the ecological footprint calculations at Campus Kindergarten to provide insight into how environmental impact can be reduced across the early childhood education sector, through the design and management of early childhood learning centres;
- Provide examples of how this information can be incorporated in early childhood sustainability education.

Scope

The scope of this study encompasses the lifecycle of all measureable goods and services consumed by the kindergarten and within its grounds, as well as transport of children and staff to and from the kindergarten (Figure 1). Processes and goods outside the system boundaries have been excluded either due to lack of information or because the footprinting technique for this process is not well defined. The basis of the study was an average year in the period 2003-2009.

Figure 1 goes here

Method

The ecological footprint for Campus Kindergarten was calculated using a method originally developed for universities (Conway et al, 2008; Flint, 2001; Venetoulis, 2001; Wang et al, 2008; Wright & Drossman, 2002). Six consumption categories were quantified: electricity, water, food, waste, transport and paper. Data was collected from a range of sources. For example, total electricity and water consumption were determined from "top down" data, i.e. utilities bills (2003-2008), and "bottom up data", i.e. direct measurements (2009) to determine where the water and electricity were being used. Transport mode and distance were determined from a survey (2009). Published Australian averages were used where site specific data was either unavailable, or in a form for which footprint conversion was excessively difficult (e.g. food consumption). Published conversion factors were used to convert consumption to land area. Many of these were drawn from EPA Victoria (2005a, b) which utilised Australian average data from the Australian Bureau of Statistics (ABS) to find the land use (in its specific categories) and greenhouse gas (GHG) emissions associated with a variety of products.

Food

CK provides morning tea for the children, and lunch and afternoon tea are supplied from home. While a food survey was conducted at the kindergarten, the variability in daily food consumption within and between individuals, the absence of data on food source and the lack of published conversion factors for many common foods meant that it was not possible to calculate a footprint for the kindergarten based on this data. Hence average Australian data was used for this impact category. Mass of food consumed by staff and children at CK was estimated from average daily consumption of different food groups (e.g. meat, dairy, cereals etc) reported in the National Nutrition Survey (ABS, 1995). It was assumed that one third of daily food consumption occurred at the kindergarten. Food mass was converted to average daily expenditure using data from published Australian Bureau of Statistics surveys (ABS, 1999; 2000; 2001; 2002; 2003), and then to land area using conversion factors from EPA Victoria (2005a, b).

Transport (commuting)

In 2009, staff and parents completed a survey on their modes of transport for travel to and from Campus Kindergarten. The survey collected information about how often they commuted to the kindergarten, the mode of transport used, distance travelled, and the origin and destination of travel. Greenhouse gas emissions produced by each survey participant were determined using emission factors for cars using unleaded petrol and diesel respectively (ACG, 2007; AGO, 2006) and for public transport (Pelkmans, De Keukeleere & Lenaers, 2001). Emissions associated with active transport i.e. walking and cycling were assumed to be negligible (Figure 1). This data was then scaled up for the total number of staff and children attending the kindergarten, assuming that the transport mode and travel distances of the survey participants were representative of the kindergarten population at large.

Utilities: power and water

Average annual direct consumption of electricity and water was calculated from data on utility bills from 2003-2008. Greenhouse gas (GHG) emissions associated with power generation were determined based on 1.04 kg CO_2-e GHG emissions generated per MWh of electricity (Brown, Searles, Cottrell, & Scaife, 2004).

The GHG emissions associated with water consumption was based on the emissions associated with the energy used to transport and treat water and wastewater used and generated at CK. The annual volume of water use was determined from council rates (2003-2008), and then used to calculate the volume of wastewater generated, using the average water supply to wastewater ratio for greater Brisbane (Kenway, Priestley, Cook, Seo, Inman, Gregory & Hall, 2008). The energy associated with water supply, treatment and transport were calculated to be 0.662 Wh L^{-1} and 0.56 WhL^{-1} for freshwater and wastewater respectively (Kenway et al, 2008), and converted to GHG emissions using the conversion factor for power generated in Queensland, as outlined above. Land area associated with reservoirs, catchments and other water supply infrastructure were not included in the study.

Energy and water audits were also performed at the kindergarten, to gain more specific data on which appliances and fittings made up the greater part of the footprint. A plug-in multimeter was used to measure the power consumption of appliances, while the water flow from taps was measured by filling a vessel of known volume over a measured time period.

Built-up land

The built up land (area covered by structures, playgrounds and paths) was calculated from CK blueprints.

Solid waste

Waste and recycled materials produced by the kindergarten were weighed over four days, at randomly-selected times in the second school term of 2009, to gain an average waste output. The recorded mass of garbage was converted to footprints using the general waste footprint, an average of all waste values (EPA Victoria, 2005a). For the toilet bins, which contained only paper towels, the footprint for paper was applied (EPA Victoria, 2005a).

Other Consumption

Consumption of miscellaneous items was assessed from Campus Kindergarten's quarterly purchasing records. Of these, office paper was the only item included in the study because, unlike other purchases, it could easily be converted to a mass basis. The paper footprint was calculated using the conversion factors provided in EPA Victoria 2005b, on the basis that CK purchases 10% recycled paper and 90% virgin paper. Other consumption items, such as drawing materials, books, teaching aids, furniture, appliances, toys, cleaning products etc. were excluded from the study due to the relatively small volume, and the difficulty in obtaining conversion factors and estimating lifespan and hence annual consumption. Thus the footprint calculated here will underestimate the true footprint of the kindergarten.

Converting to Global Hectares

Land required to absorb Greenhouse Gas Emissions (GHG) (described as "carbon land") was determined on the basis that 0.2675 gha of forest is required to absorb one tonne of CO_2 (EPA Victoria, 2005b). Land usage not associated with absorption of GHG emissions was converted to global hectares using a yield factor (YF) and an equivalence factor (EF). The yield factor is the ratio of the yield from land in the country from which the material was sourced, to the global yield for land of the same type. The equivalence factor is the ratio of the average productivity of a land type to the average productivity of all land types (Kitzes et al. 2007). Hence, the overall formula for determining the footprint of a good in global hectares is:

$$EcologicalFootprint(gha) = \frac{Mass(kg)}{Yield(kg/ha_{source})} YieldFactor\left(\frac{kg/ha_{source}}{kg/ha_{global}}\right) EquivFactor\left(\frac{kg/ha_{global}}{kg/gha}\right) \quad (1)$$

The ecological footprints of each individual component were converted to global hectares using Equation 1 and Table 1, and then summed to produce the final ecological footprint.

Table 1 goes here

Results

The total ecological footprint of Campus Kindergarten was found to be 37.8 global hectares (gha) (Table 2). However, in addition to the land required to produce goods and services used by humans, space is also required for other species, i.e. biodiversity. This reflects the fact that using the entire surface area of the planet for human activities or production would not be sustainable. Since healthy ecosystems are essential for the provision of clean air, water and food production through "ecosystem services", we need to provide sufficient land area for diverse, resilient, sustainable ecosystems (Viousek et al. 1997). One way to account for this is to scale up all footprints by 12% (EPA Victoria, 2005b). Allowing for biodiversity, CK's footprint is 42 gha (0.56 gha per child), which is only 25-50 % of per capita footprints calculated in university and school studies (Conway et al, 2008; Flint, 2001; Venetoulis, 2001; Wang et al, 2008; Wright et al, 2002).

Table 2 goes here

There will be substantial variability and uncertainty inherent in the figures summarised in Table 2. Even so, these results provide an initial quantification of the land area required to support the activities associated with children attending an Australian early learning centre, and show where the major impacts occur. For this reason, and to support associated educational activities, the information in Table 2 is summarised in a "footprint" for each child (Figures 2, 3) rather than traditional bar graphs.

Figure 2 goes here

More than half of the footprint was land required to capture and absorb greenhouse gas (GHG) emissions (Figure 2). Almost all this "carbon footprint" was associated with fossil fuel consumption (transport, energy) and emissions associated with food production (Table 2). Hence reducing activities which generate GHG emissions will be very important in reducing the overall footprint of the kindergarten.

Figure 3 goes here

The consumption categories which had the greatest impact on the overall footprint were food, electricity consumption and transport (commuting), accounting for 61%, 15% and 22% of the footprint respectively (Table 2, Figure 3). This differs from school and university ecological footprint studies, where electricity is consistently the main contributor (Conway et al, 2008; Flint, 2001; Venetoulis, 2001; Wang et al, 2008; Wright et al, 2002), with food consumption often coming third. This reflects the more energy intensive activities conducted in schools and universities compared to early childhood education services, which uses a comparatively small amount of electrical equipment.

Together, food, electricity consumption and transport accounted for 98% of the CK footprint (excluding biodiversity); hence any substantial reduction in the footprint will require reductions in these areas. Meat and dairy consumption accounted for 27% and 34% respectively of Campus Kindergarten's total food footprint; hence the large area of pasture land required (Figure 2). Since the impact of food consumption was calculated using national averages, these results suggest that food consumption will be a major contributor to the total impact of typical Australian early learning centres.

Commuting accounted for almost a quarter for the CK footprint (Table 2). 69% of trips were by car travel, 4% by bus, and 27% by walking or bicycle. The average distance travelled to the kindergarten was 7.9 km and the average distance per car trip was 9.2 km. The average distance for active transport (cycle/walking) was 8.7 km. The survey was completed by 33% of the kindergarten population; if survey participation is biased towards people with an interest in sustainability, the transport impact calculated here is likely to be an underestimate.

The energy footprint was due to GHG emissions during production of electricity. This could be reduced through both reduction in power consumption and change to power source, e.g. subscribing to a renewable energy supplier or installing solar panels for generation of electricity on site. Lighting and air-conditioning made up the largest part of the energy footprint (84%). Installing more energy efficient appliances, switching to low wattage bulbs, and reducing air conditioning energy consumption (e.g. changing room temperature set point, or using fans and natural ventilation instead) may reduce energy consumption, and the corresponding energy footprint.

From the water audit performed on the bathroom and kitchen taps, it was found that 22% of the total water footprint arose from hand washing. Hand washing is vital for public health, and should not be reduced. The average measured flow rate from the taps was found to be 5.52 L/minute which complies with the Brisbane City Council Standards for water saving taps. However further reductions in water used in washing may be possible by recent advances in water-saving devices.

57% of solid waste at the centre is recycled, which substantially reduces solid waste and is likely to be a consequence of a decade of waste reductions as part of the centre's 'Sustainable Planet Project". Reducing paper usage would reduce the solid waste footprint at CK, but further reductions in this area may not be practical. The second largest part of the solid waste footprint was made up of paper towels used in the bathroom. Replacing paper towels with reusable fabric towels should be investigated from environmental, health and economic perspectives. Currently, the Campus Kindergarten uses 10% recycled office paper. Converting to 100% recycled paper would reduce the paper footprint by 37%, but this would not have a major impact on the overall footprint.

Discussion

Our calculation of the land area required to support the day-to-day activities, transport and consumption per child at CK are laid out in Figures 2-3, where each square represents an area of 100 m^2, i.e. 10 m by 10 m. While the exact numbers are subject to uncertainty and variability, the main point is clear; the land required to support our lifestyle is a lot more than we physically occupy. We propose that Figures 2-3 be used by early childhood educators to introduce the concept of ecological footprint to young children as a key part of their early education for sustainability. One simple way to implement this is to mark out in the playground the land required to support one child at an early childhood centre (Figure 2). If the playground is not large enough, a map of the early learning centre could be drawn, and the children each given their own "footprint" created to the scale of the map. The children could then be asked to put their footprints over the map, and so see how much land is required to support them alone at kindergarten, and how much is required for all the children.

Once the concept of ecological footprints has been developed in a concrete, visual manner, it can be explored in a wide variety of ways. For example, teachers can help the children break the footprint into its 6 components using either Figure 2 or 3, then explore with children exactly what each type of land is for, and decorating the footprint accordingly. This will involve introducing two important concepts: the requirement for land to be set aside for healthy ecosystems (Biodiversity land), and land required for carbon cycle functioning. Teachers can also explore wider implications with children, such as conceptualising the total footprint per child, including that created outside of kindergarten, and the footprint of other people in the world. This could lead to discussions about finite resources; our planet is a certain size, and we need to make sure that we don't use it all up! The core concepts of sustainability are essentially about sharing, thus are an extension of an issue young children grapple with on a daily basis.

A suitable follow-up to visualisation of their footprint and discussion of its significance is to question how it can be reduced, so there is enough room on Earth for all of us to live a good life. Children can be actively involved in programs to reduce the footprint of their early childhood centre, using some of the suggestions outlined below and the information contained in Table 2 and Figures 2-3. Importantly, this does not involve reducing the size of the playground. Our results indicate that reducing the land area of an early learning centre will have a negligible effect on environmental impact as measured by the ecological footprint, while the benefits to children of adequate playground space are well documented (Maller, 2008). The ecological footprint of the kindergarten was more than 190 times the area of land physically occupied, even though the per capita area of CK is large. CK's area is equivalent to 110-130 m^2 for each child, which is more than a factor of 10 higher than either Queensland requirements, or the Canadian standard of 10 m^2/child (Beach & Friendly, 2005), yet it accounts for less than 1 % of the footprint.

This study suggests that the footprint of a kindergarten can be reduced by making different food decisions. The effect of diet is significant and suggests possibilities for community education on the varying impacts of different foods. While parents have the greatest control over their children's diets, early learning centres have opportunities to teach children and families about the connection between food consumed and land area required for food production. Establishing a fruit and vegetable garden or a chicken coop would be an engaging and educational way to demonstrate the processes of food production, introduce the health and environmental benefits of using locally grown, seasonal fresh produce and, at the same time, lowering a centre's food footprint.

Transport options used by children, which make up a significant part of any footprint, are ultimately decided by parents. While there are some limitations to transporting young children using active and public transport, there are a number of ways in which early childhood centres can support parents to choose these lower impact options. Bicycle use and walking can be encouraged by providing safe and secure storage areas for bicycles and prams. Centres may also provide information about public transport choices for parents at time of enrolment, e.g. summarising the nearest train, bus and ferry stops, and the route numbers. Facilitating car-pooling and encouraging active transport have the potential to both reduce emissions associated with transport, and provide social benefits as parents and children have opportunities to meet and spend time together with other members of their local community. In the long-term, locating new early childhood education centres adjacent to schools, transport hubs and workplaces is vital to reduce car usage and the associated environmental and social issues (e.g. traffic congestion, lack of physical activity, fossil fuel consumption).

As outlined in the results there are a number of ways in which the energy footprint of existing early childhood centres can be reduced, including installing solar panels, receiving renewable energy from the supplier and promoting smaller energy conservation measures (e.g. switching off lights and appliances when not in use, ensuring air conditioned rooms are closed off). These measures also present learning opportunities. Teachers can work with children to facilitate investigations of the science of electricity, where it comes from, the impacts associated with different energy sources, and how to incorporate energy-saving behaviours into daily routines. Already, there are preschools and early childhood centres that use and learn about energy conservation (for example, Bates & Tregenza, 2007; Pratt, 2010).

However, the ongoing energy consumption of the early childhood centres will be largely determined when the buildings are first designed and constructed. For example, energy-efficient design can reduce household energy consumption by up to 60-70% (SEAV, 2002), and can reduce energy consumption in high rise buildings by 30% (WCAE, 2009). Hence new early childhood centres should be designed for minimum energy consumption in order to reduce the carbon footprint and associated environmental impacts across the sector. Existing early childhood centres can also reduce heating and cooling requirements by retrofitting and insulating buildings and planting gardens and trees to enhance direct sunlight and minimize airflow in winter, and vice versa in summer.

Clearly, reducing consumption at all levels is the key to reducing environmental impact. The challenge for early education centres is how to enhance educational benefit while reducing impact. For example, water play has been a 'traditional' play and learning strategy in early childhood education, although this has been challenged in recent years as parts of Australia have grappled with drought and water restrictions. Children at CK have actively engaged in learning and problem-solving about water conservation as have several other early learning centres (see Davis, Miller, Boyd, & Gibson, 2008). As with electricity, it is worthwhile engaging children in water conservation and water education at the centre and to identify ways to reduce water use at home (for example, taking short showers, turning off taps). The evaluation of the *Early Childhood Water Aware Centre Program* (Davis et al, 2008) has shown that parents are, indeed, positively influenced by water conservation messages that children transfer from their early learning centre into their homes.

The waste footprint at CK was small relative to other impacts, a finding that is consistent with other footprint studies (Flint, 2001; Venetoulis, 2001); consumption of resources typically has a higher impact than waste disposal, and the full impact of waste is difficult to quantify in an ecological footprint (Kitzes & Wackernagel, 2009). CK applies a range of measures to minimise waste, using the waste hierarchy of 'reduce, reuse and recycle', which may also contribute to the low footprint of the kindergarten's waste. Waste is significantly reduced by encouraging parents to pack 'litterless lunches'. Individually packaged food items are discouraged in favour of buying food in bulk and using reusable containers. Food that requires no packaging is preferred and is often healthier, e.g. fresh fruit instead of processed food bars. Waste paper is reused where possible and the majority of food scraps are composted. Application of similar systems of waste reduction, reuse and recycling has the potential to minimise waste across the early childhood education sector, and more importantly, educate children about waste reduction which will contribute to the societal changes required to conserve our resources and live more sustainably.

Converting a complex array of data into one uniform unit, the ecological footprint makes it easy to conceptualise the size of impacts. However it is not possible to accurately summarise all environmental impacts into one number (Conway et al. 2008; Mitchell 1996). There are many limitations to the ecological footprint, including uncertainty and variability in data, inaccuracy associated with assumptions, poor repeatability due to a lack of a standardised calculation method, and the neglect of environmental impact categories (e.g. pollution and water use) which would affect the sustainability of an area (Barrett et al, 2004; Conway et al. 2008; Flint, 2001; Lenzen & Murray, 2001). While there will always be large uncertainty in the final value calculated, the ecological footprint does accurately demonstrate that the land area required to support human consumption is orders of magnitude larger than the land we directly occupy (Kitzes & Wackernagel, 2009; Rees 1996).

Just as the land required to support the kindergarten is more than 190 times the land area that it occupies, so too water consumption associated with other forms of consumption is likely to greatly exceed the water consumed on site (cf. Hoekstra & Chapagain, 2007). Since the ecological footprint does not wholly take into account the embedded water, that is, the water used when supplying a good or service, or the impact of land use on water quality (Kitzes & Wackernagel, 2009), a similar project should be undertaken to determine the water footprint of an early learning centre. This could be used, like the ecological footprint, to provide children with concrete visualisation of water used out of sight to support their lifestyle. For example, the volume of water required to generate one cup of milk could be measured out, and water play used to demonstrate the difference, with children emptying or filling the "embodied" volume with a cup.

Conclusions and Recommendations

This study has provided an ecological footprint for a kindergarten and offered suggestions as to how this can be used for education purposes, thus helping – in a small way - to close the research gap in early childhood education for sustainability. This prototype ecological footprint calculator has the potential to be developed more fully so that it can have wide use within other early childhood centres to assist them to think about and change their consumption patterns and behaviours. Such a tool has the potential to 'scale up' change for sustainability more broadly within the early childhood education sector. At the same time, it has fostered interdisciplinary research links which many researchers realise offer new ideas and solutions to our sustainability problems. Thus, in this study, engineers and educators working together have identified that the largest contributors to the kindergarten footprint were food, transport choices and energy use. They have also determined that impacts can be reduced through a combination of:

- Education: educating teachers, children and their families about the land required to generate food, the impacts of different food choices (type of food and source) and the importance of using the Earth's resources sustainably.
- Infrastructure: designing and retrofitting early childhood learning centres to minimise energy required for heating, cooling and lighting; locating new centres near transport hubs, schools and workplaces; providing facilities to encourage active and public transport by staff and families;.
- Practice: minimizing waste in early childhood education settings through application of the waste hierarchy; reducing consumption where possible (e.g. using alternative energy sources, purchasing low energy appliances, installing water efficient devices, turning off appliances not in use, using rainwater tanks for outdoor play), reusing (e.g. using reclaimed materials and paper for artwork etc) and recycling (e.g. worm farms and compost bins).

This and subsequent studies may be used to present the concepts of sustainability and the impacts of specific environmental processes and choices to children (Cordero et al, 2008) and their wider communities. Since parents have the most control over the two largest footprint contributors, food and transport, dialogue and cooperation between families and educators is vital for reducing a centre's environmental impact. As other studies have shown, young children are capable of learning and acting for sustainability and parents have been shown to change their environmental behaviours as a result of ideas generated through their children's environmental learning at kindergarten or daycare (Davis et al, 2008).

When discussing environmental and sustainability issues, it is common to present the causes primarily as those of large industry and governments. It is hoped, instead, that using ecological footprints will show that environmental protection and living sustainably is everyone's responsibility. When used sensitively in an early childhood educational setting, children can be encouraged to use life-cycle thinking and to consider the impact of everyday goods and services right back to their production. Educating for sustainability at an early age provides small, but vital, steps towards creating communities with high levels of environmental consciousness into the future.

Acknowledgements

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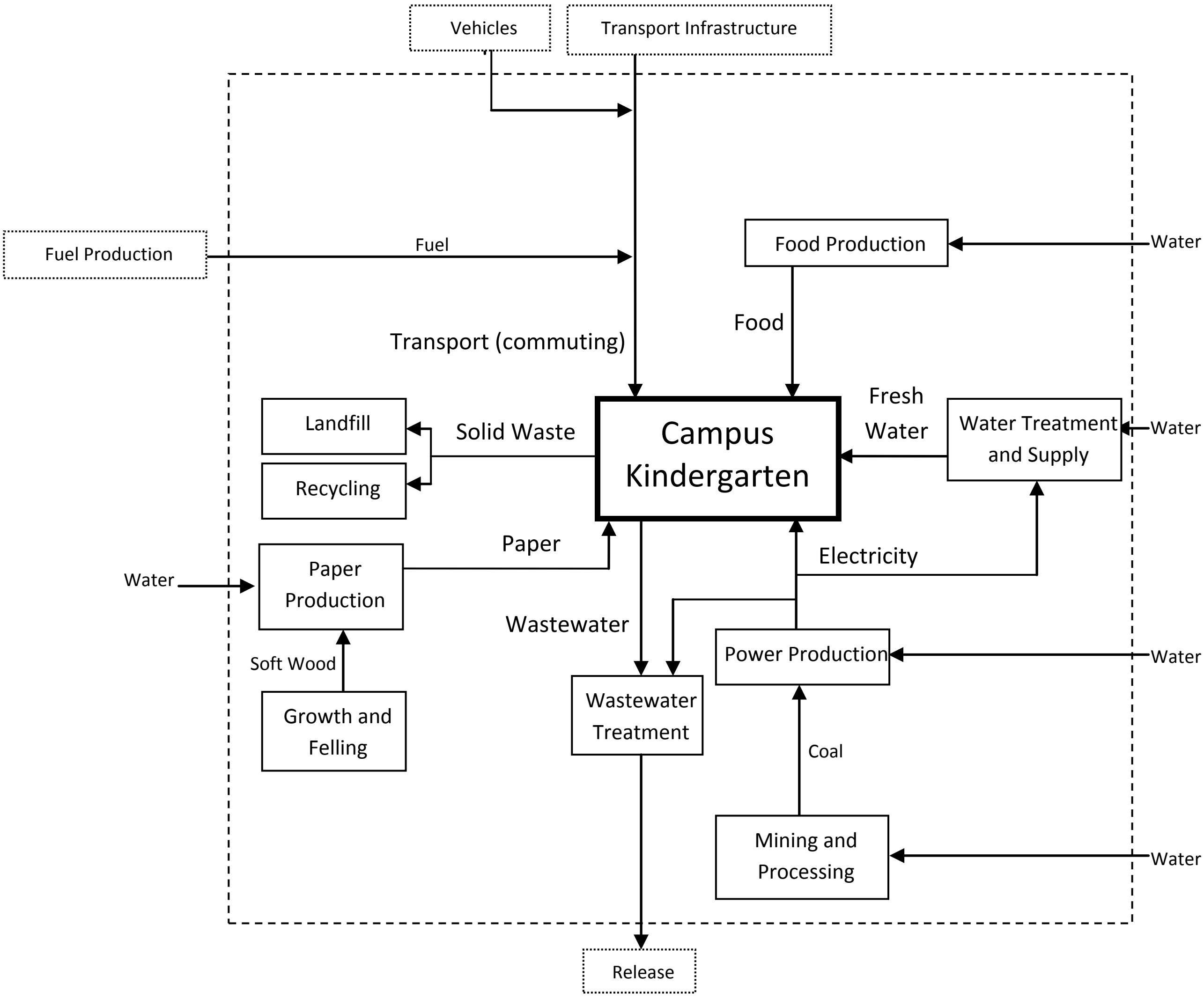

Figure 1: Scope of Study (dashed line indicates system boundary)

Table 1 – Yield and Equivalence Factors for Australia (EPA Victoria, 2005b)

Land Type	**Equivalence Factor (gha/ha)**	**Yield Factor**
Primary Cropland	2.19	0.9
Marginal Cropland	1.80	0.84
Pasture	0.48	0.18
Forest	1.38	0.31
Built Up Land	2.19	0.9

Table 2 – Breakdown of the ecological footprint of Campus Kindergarten, excluding biodiversity

	Carbon Land (gha)	Pasture (gha)	Cropland (gha)	Forest (gha)	Built up (gha)	Total (gha)	% of total
Food	8.05	7.98	3.71	2.81	0.38	22.9	61%
Transport	8.64	0	0	0	0	8.4	22%
Energy	5.78	0	0	0	0	5.8	15%
Paper	0.24	0	0	0.02	0.00094	0.3	0.7%
Built Up Land	0	0	0	0	0.22	0.2	0.6%
Water	0.11	0	0	0	0	0.1	0.3%
Solid Waste	0.084	0	0	-0.015	0	0.07	0.2%
Total	22.7	7.98	3.71	2.81	0.6	**37.8**	
% of total	60%	21%	10%	7.5%	1.6%		

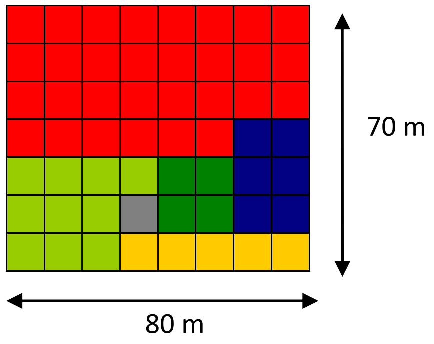

Figure 2 – Ecological footprint per child at Campus Kindergarten, broken into land-use types, where Light Green indicates Pasture land (for animal grazing to produce meat and dairy products: 0.10 gha, i.e. 1000 m^2 per child); Yellow is Cropland (to produce crops, such as fruit orchards and wheat fields: 0.05 gha, i.e. 500 m^2 per child); Dark Green is Forest (to grow wood for forest products, such as paper: 0.04 gha, i.e. 400 m^2 per child); Grey is Built-up land (0.01 gha, i.e. 100 m^2 per child); Blue is land required to maintain biodiversity for healthy ecosystems (0.06 gha, i.e. 600 m^2 per child) and Red indicates Carbon Land (for vegetation to absorb greenhouse gas emissions generated from fossil fuels and agriculture: 0.3 gha, i.e. 3000 m^2 per child).

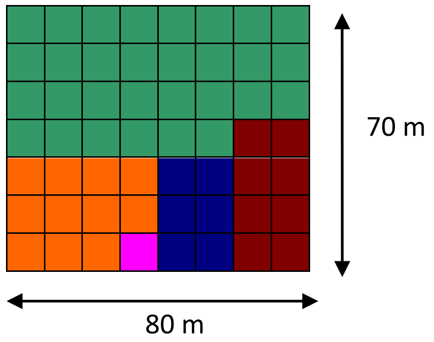

Figure 3 – Ecological footprint per child at Campus Kindergarten, broken into consumption types, where Green indicates land required for Food production (0.30 gha, i.e. 3000 m^2 per child); Orange is land required to absorb Transport emissions (0.11 gha, i.e. 1100 m^2 per child); Brown is land required to absorb emissions associated with energy production (0.08 gha, i.e. 800 m^2 per child); Blue is land required to maintain biodiversity for healthy ecosystems (0.06 gha, i.e. 600 m^2 per child) and Pink indicates Built-up land and land associated with paper production, water supply and solid waste (0.01 gha, i.e. 100 m^2 per child).

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