The impact of the loss of land to urban development on agriculture in Kent.

Frances Heather Robbs de la Hoyde

BSc Zoology

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Prof. Les Firbank

Faculty of Biological Sciences

University of Leeds

LS2 9JT

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1. Abstract

Anecdotal information regarding the loss of agricultural land and other green space to urban development in Kent is plentiful, but there is a lack of information on the impact of this loss. This study aimed to quantify the loss of agricultural land, and provide data on the losses to the agricultural sector due to urbanisation. Using Ordnance Survey maps and development plans provided by the 13 borough councils of Kent, the area of loss for six land types was quantified using ArcMap 10.4.1. The loss to agricultural land in the 2003-2031 period that the development plans covered was 780.81 ha. The resulting impact on the monetary outputs of the agricultural sector was estimated at just under £4 million, or approximately 0.017% of the UK's agricultural outputs. Further estimations from Kent County Council (KCC) on population growth state that 158,500 additional housing units are required, additional to development plans, by 2031. Providing that development follows land use trends, the additional losses of this development could cost Kent's agricultural sector 9.26% of its outputs. The study of the impacts of urban development on agriculture provides information that is central to the decisions made by the Borough Councils regarding locations for future developments.

Keywords: Kent, urban development, agricultural productivity, agricultural self-sufficiency, population growth, food availability

2. Introduction

The loss of agricultural land is well documented in the media, but there is little literature on what the effects of the acquisition of new land due to urbanisation might be on agriculture and food supply. Urbanisation is defined as 'the process of urban development and is characterized by the expansion of built-up areas' (Ren, G. 2015): the effects of the loss of agricultural land to urbanisation in the UK are expected to be wide ranging, with concern currently being placed on the effect on national food availability. Expansion of urban settlements has led to wide-scale land use changes across the UK, with 225,200ha having shown a change in land cover between 2006 and 2012 (University of Leicester. 2015). In combination with fears over the future of the UK's import and export status following 'Brexit', urbanisation in the UK indicates that it is appropriate that more research is undertaken into self-sufficiency in the UK. The rate of urban development in Kent and the consequential reduction in farmland may be used as an example for the rest of the UK and provide grounds for a more expansive future study.

Land lost to urban development may not exclusively be agricultural land; a number of other ecosystem services may be affected as well. Ecosystem services are defined as 'the benefits gained by humans from ecosystems' (Reid, W. et al. 2005). The acquisition of rural land for development will have a wide ranging impact on ecosystem services which may include agricultural and self-sufficiency impacts and the associated economic impacts, biodiversity impacts (including green infrastructure), geographic effects and social impacts.

A 2004 study into the loss of arable land to urban development in China found that the urban area of the Beijing-Tianjin-Hebei region expanded by 71% between 1990 and 2000. It was found that 74% of this land was acquired from arable functions; this figure was even higher for smaller cities at 81% (Tan, M. et al. 2004). In 2000, China had an average of 0.11ha of arable land per person, less than half the global average; and while this is partly to do with the fact that China has the highest population of any country, the acquisition of their arable land for urban expansion has played a huge role contributed to this low area. It was estimated that 0.31 million ha of arable land was lost per year during that period; a large area of land to be removed from the agricultural system of a country with a booming population.

In a similar way to this large study in China, here this study aims to investigate land use changes in terms of urbanisation and agricultural land. It exemplifies the suitability of studies of this type into urbanisation and food security on a global scale, which is of concern due to global population growth. The rate of agricultural land loss in Kent is of note, with potential implications for food security in Kent and in the UK as a whole. To quantify the area of land lost in Kent and the productivity of this land would allow for input to future planning decisions in the county to be more calculated.

2.2. Kent

The county is of interest due to a combination of the high levels of development (Kent County Council. 2013), and the value of the agricultural sector, which is believed to be around £226mn (Kent County Council. 2009). The agricultural industry contributes an estimated 1.1% of the Gross Value Added (GVA) to Kent, and while this contribution has been declining, forecasting by Experian for KCC predicts a small amount of monetary growth in the sector between 2019 and 2025 (Kent County Council. 2009). The location of Kent within London's commuter belt (Hardill, I. et al. 2006) puts pressure on its housing markets & pushes for urban expansion in the region.

A high population density and demand for houses has led to extensive development in the county (Fraser, I. 2016), which may be disproportionate to the rest of the United Kingdom. However, Kent can be used as a strong example of a well-developed county with areas of high GVA: in 2014 the GVA per capita in Dartford was £30,369 (Kent County Council. 2016), compared to a UK GVA of £24,958. Predictions for the impact on agriculture in Kent may therefore be used to inform about potential nationwide impacts of urbanisation.

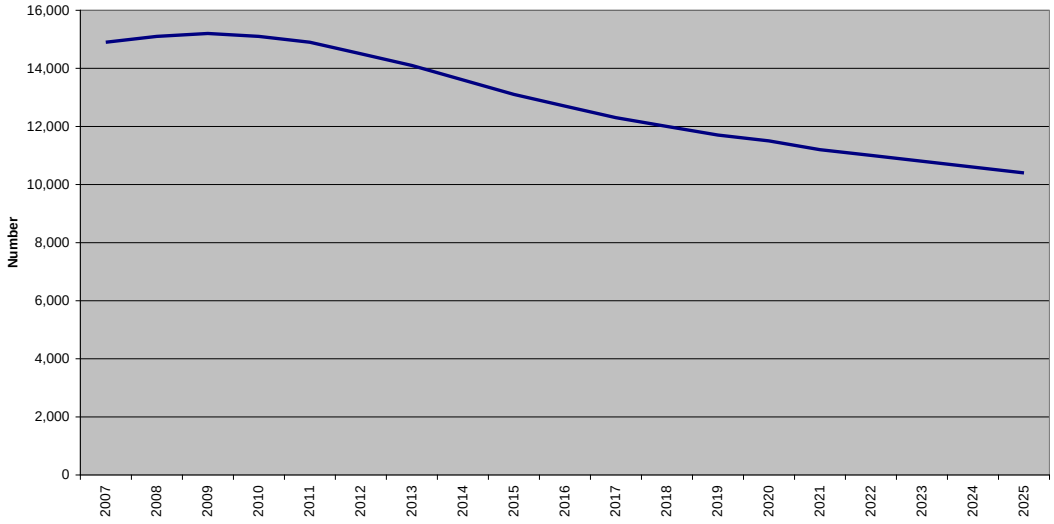

Figure 2.1- forecast of total employment in Agriculture, Forestry and Fishing in Kent, 2007-2025 (KCC. 2009).

Kent is one of the Home Counties, with a population of approximately 1.5m and a number of large towns and cities. It is estimated that approximately 13,000 workers are employed in agriculture in Kent, many of whom are seasonal workers (KCC. 2009). A decrease in agricultural employment is forecast for 2025 (Figure 2.1), and although agriculture only makes up 2.3% of the employment in Kent, any further decrease in the employment in the sector would be expected to have economic consequences on the region. Kent's location in the fruitful South East of England makes it a suitable area for the study of this subject, and the county's

status as the ‘Garden of England’ – due to its fertile soils, large number of hop gardens and fruit orchards – only solidifies the agricultural importance of the region.

2.3. Further impacts of urbanization

Biodiversity is affected by urbanisation: it has been shown to eliminate the majority of native species (McKinney, M. 2002) and reduce local populations. Biodiversity loss is tied tightly with the loss of urban greenspaces; natural habitats are fragmented into smaller patches and much of the land is transformed into either buildings, roads, or managed vegetation (McKinney, M. 2002). Natural habitats are often found in the parks and large gardens of cities, but as this is broken down, habitat loss leads to decreased biodiversity. Urbanisation also creates barriers to ‘green corridors’. Green corridors are links of natural land between larger areas of landscape, and are commonly found as ‘channels’ in and out of urban areas. They ‘facilitate the movement and migration of wildlife’ (Mu, S. et al. 2014), and are therefore essential for promoting the continuation of urban populations of species. However, fragmentation of green sites within green corridors reduce the means for the movement of wildlife, and are therefore detrimental to urban biodiversity. Fragmentation and the associated ‘edge effects’ are considered one of the largest threats to the security of regional, national and international biodiversity (Henle, K. 2004). Habitat loss often leads to a habitat being broken into a number of ‘patches’, creating a habitat which overall has a larger number of edges relative to area. Edges are often the location of interactions between biota that influence the community, and may not be obvious to the human eye; they may simply be the range of an individual within any species in the community.

The effects of urbanisation do not solely include outwards fringe expansion but also the redevelopment of existing buildings, termed ‘Urban Renewal’. This development has been found to have negative impacts on the quality of life of those living in the area of urban renewal, especially in destruction phases (Cheung, C. and Leung, K. 2011). In addition to this, lifestyles may be affected by the acquisition of public land for developments, including parks and other green spaces. Studies have found a lower prevalence of a number of diseases for those living in environments with a higher percentage of green space in the surrounding 1km, especially for anxiety and depression (Maas, J. et al. 2009). A 2009 study by Maas et al looked at the effect of lack of green space - due to urbanisation and spatial densification - on human health in the Netherlands. Morbidity indicators were established by using primary care records from GPs: all participants had at least 12 months medical records with that GP. The data regarding quantity of green space were taken from the National Land Cover Database, which then allowed each participant’s postcode to be classified for dominant land use. The percentage of ‘green space’ in both a 1km and a 3km radius of each individual’s address, and used in

conjunction with the 'urbanicity' of the area. The relationship between green space and morbidity was then investigated, with the prevalence of 15 out of 24 diseases being lower in areas with a higher percentage of green space. Mental health diseases such as depression and anxiety had the strongest inverse relationship with percentage of green space; there should be concern over the impact on mental and physical health if urbanisation leads to the removal of parks and woodland.

3. Hypotheses, aims and objectives

3.1. Hypotheses:

The area of each land type proposed for development will be studied for demonstration in real terms and proportionally, with derelict land ('land that has become damaged beyond beneficial use without treatment' (Lawson Fairbank. 2015)), development on aquatic land (e.g. ponds, reservoirs), woodland, agricultural land and recreational land making up the land types allocated for development.

The acquisition of agricultural land (arable or livestock) in Kent will be investigated to see if there is a negative effect on the agricultural productivity of the area, which would have had a secondary impact on the self-sufficiency of the UK.

The study will show the change in rate of development in Kent in the upcoming years, and therefore it's changing effect on the quantity of farmland available for food production. This study will also see discussion into of the impact of this on the future of self-sufficiency in the UK.

3.2. Aims and objectives:

To provide an analysis of the impacts of land use change on agricultural productivity in Kent, in order that the charity, Campaign to Protect Rural England (CPRE) may use this information to contribute a balanced argument to further proposals for development in the area.

Where possible, the impacts should be quantified in a form that allows a reasonable conclusion to be drawn regarding the future of land use in Kent. When appropriate, the predicted impacts of urbanisation in Kent should be used to make suggestions for more expansive studies across the UK.

4. Methodology

An evaluation of the land types that were earmarked for development over a period between 2003 and 2031 was undertaken by analysing development plans alongside Google Earth (Google. 2016 A) images for land use. Development plans are a series of maps and the

associated documents that are required to be released by every borough council in the UK; they illustrate the areas in which new developments are planned, from housing to leisure sites. They are sometimes called ‘Site Allocations Local Plan’, the ‘Local Plan’ or the ‘Core Strategy’, and set out the areas which are set aside for development – of housing, employment development, education etc – in a certain time frame. These consist of plans that have been approved by councils for development, and therefore do not include plans that are currently being considered. These data were used in conjunction with data on agricultural productivity and outputs from a number of sources, in order to assess the impact on agriculture in Kent.

4.1. Development mapping

This study was undertaken using ArcMap 10.4.1, and Ordnance Survey maps which were available through Digimap (Digimap. 2016); this website allows access to all OS maps for the UK. The mapping area for each borough of Kent was imported from Digimap to ArcMap, as shown in Figure 1. ArcMap was appropriate for this as it allowed the compilation of data from two mapping sources. The area of the borough was estimated using observations with GoogleMaps (Google B. 2016 B), and the type of Ordnance Survey map downloaded was ‘VectorMap Local Raster’ in full colour as this showed sufficient detail for overlay maps to be constructed. Once the data was downloaded, the files were ‘unzipped’, at which point they were available for upload to ArcMap.

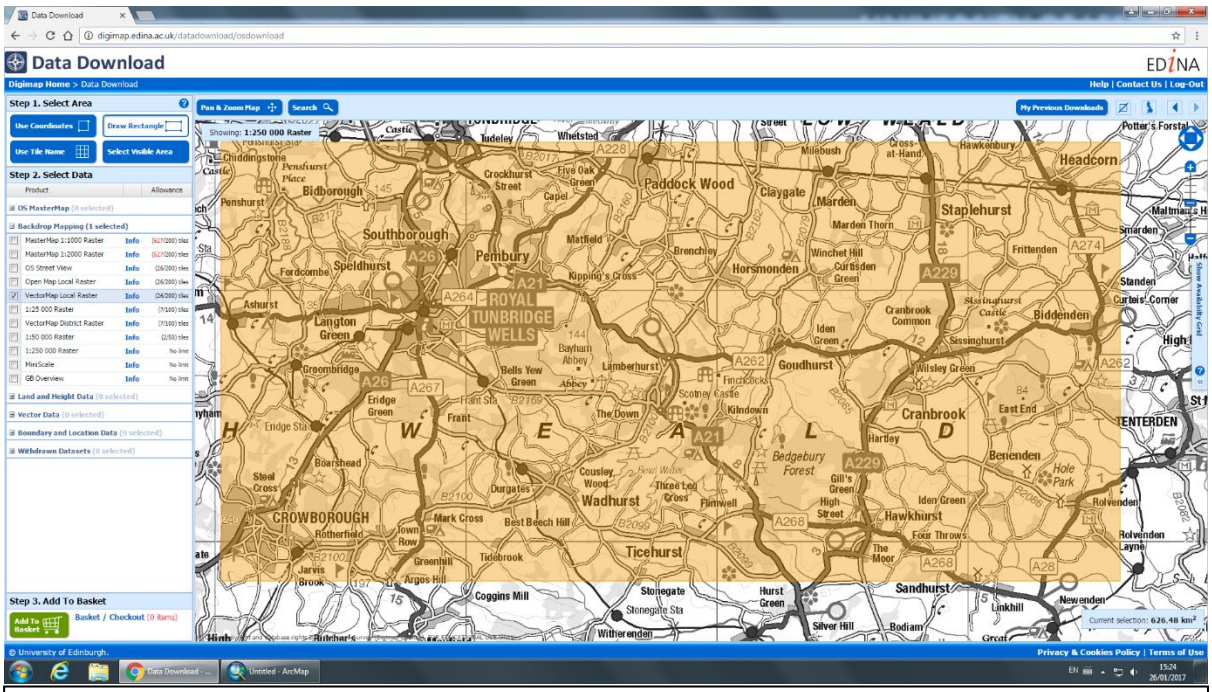

Figure 1 – screengrab showing download of Tunbridge Wells borough map on Digimap

The areas that each borough council had allocated for development were accessed via the 'Adopted Development Plan' documents, which were available on each respective borough council's website (see Figures 2 & 3).

Borough	URL	Time span
Sevenoaks	http://www.sevenoaks.gov.uk/services/housing/planning/local-plan-and-planning-policy/allocations-and-development-management-plan	2015-2026
Dartford	http://www.dartford.gov.uk/by-category/environment-and-planning2/new-planning-homepage/planning-policy/adopted-plans	2011- 2018
Gravesham	http://www.gravesham.gov.uk/home/planning-and-building/local-plan/gravesham-local-plan-core-strategy	2014-?
Tonbridge and Malling	https://www.tmbc.gov.uk/services/planning-and-development/planning/local-development-framework/ldf/2856	2007-2021
Medway	http://www.medway.gov.uk/planningandbuilding/localplansandpolicies/medwaylocalplan2003.aspx	2003-?
Maidstone	http://www.maidstone.gov.uk/business/planning/local-plan	2011-2016
Tunbridge Wells	http://www.tunbridgewells.gov.uk/residents/planning/planning-policy/local-plan	2006-?
Swale	http://www.swale.gov.uk/local-plan-for-swale/	2008-2031
Ashford	http://www.ashford.gov.uk/development-plan-documents	2006-2021
City of Canterbury	https://www.canterbury.gov.uk/planning/local-plan/adopted-local-plan-documents/	2006-?
Shepway	https://www.shepway.gov.uk/planning/planning-policy/local-plan/core-strategy	2013-2026
Thanet	https://www.thanet.gov.uk/your-services/planning-policy/thanets-new-local-plan/what-is-the-new-local-plan/	2006-2031

Figure 2: development plan URLs and time span for each development plan

In many cases, this was accessed as an interactive map, and in others it was a series of static maps. In the case of interactive maps, only the relevant overlays were applied to the map. This meant that the map had less unnecessary information, as information irrelevant to the study such as flood plain information was not included. In cases where the relevance of the overlay was unclear, reference was made to the Core Strategy Documents – the accompanying documents which provide information on individual sites – for clarification.

Screengrabs were taken of those sections of the borough that included land earmarked for development (see Figure 3) i.e. it was not necessary to take screengrabs of those areas in which there are no development sections. Care was taken to ensure that these screengrabs were taken on a small enough scale, usually a minimum of 1:500 (multiple screengrabs were normally required in order to cover the entire area). This ensured that when the maps were overlaid on the Ordnance Survey map, they were at a high enough resolution to accurately draw polygons surrounding that area.

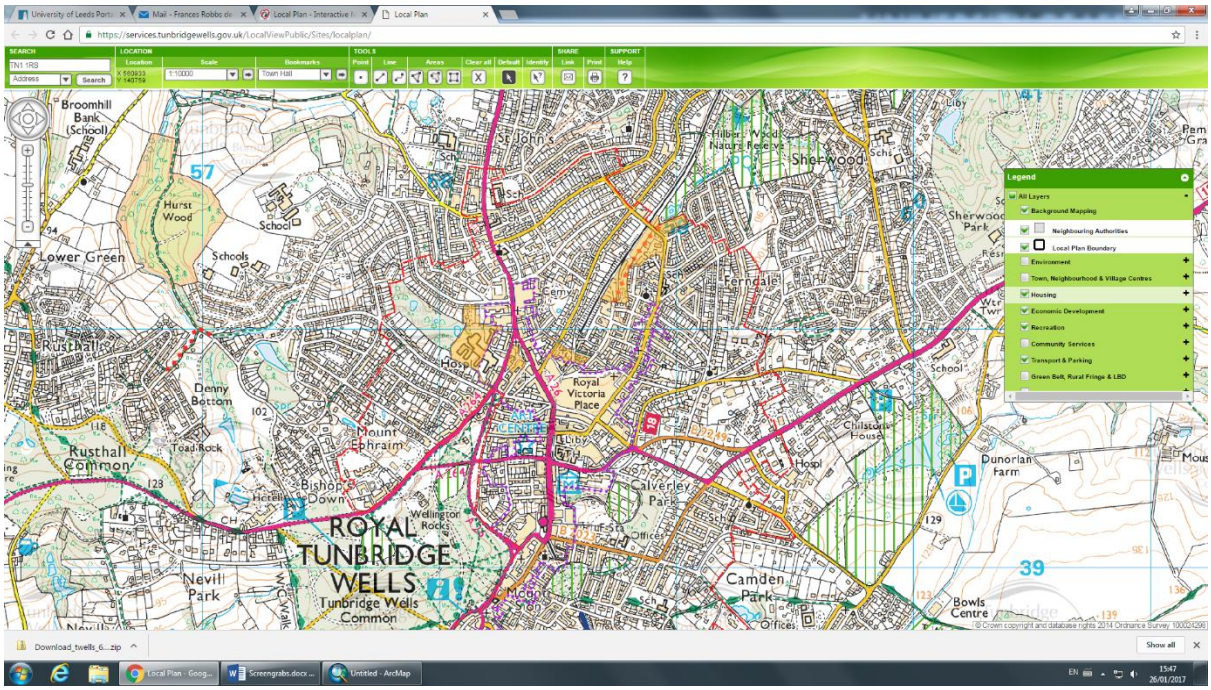

Figure 3 – screengrab showing development overlays on Tunbridge Wells Borough Council development plan interactive map.

Each screengrab was individually uploaded to ArcMap, where it was georeferenced to ensure that it was overlaid on the correct area of the Ordnance Survey map. This required a notable location on the development area being identified; normally this was a crossroads or roundabout. The same location was identified on Google Maps (Google. 2016 B), which provided the decimal lat/long figure. The British Geographical Society coordinate converter (BGS. 2017) was used to convert this figure into an Easting/Northing of the British National Grid. These grid references were then used to georeference the development map, as is seen in Figure 4. At least 4 separate grid references should be used in order to position the overlay accurately and at the correct scale. In some cases, the georeferencing did not lead to the accurate positioning of the development plan map, and the ‘shift’ tool was used to calibrate the location of the map.

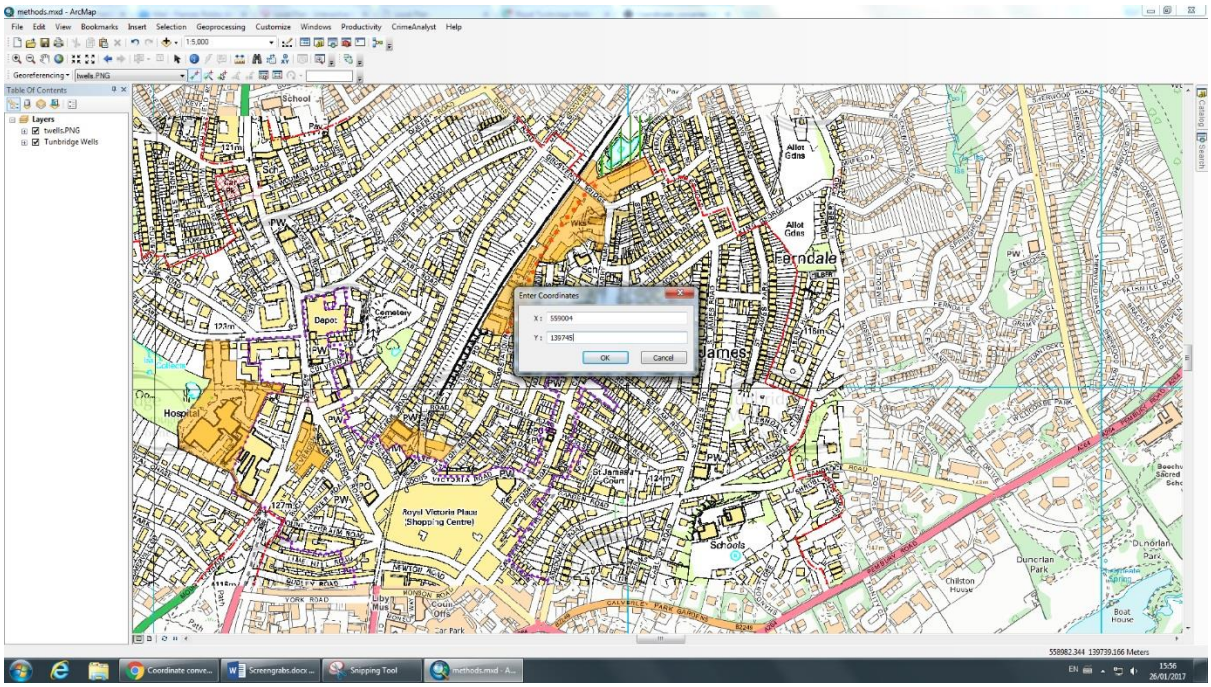

Figure 4 – screengrab showing the georeferencing of a section of Tunbridge Wells Borough Council development plan map.

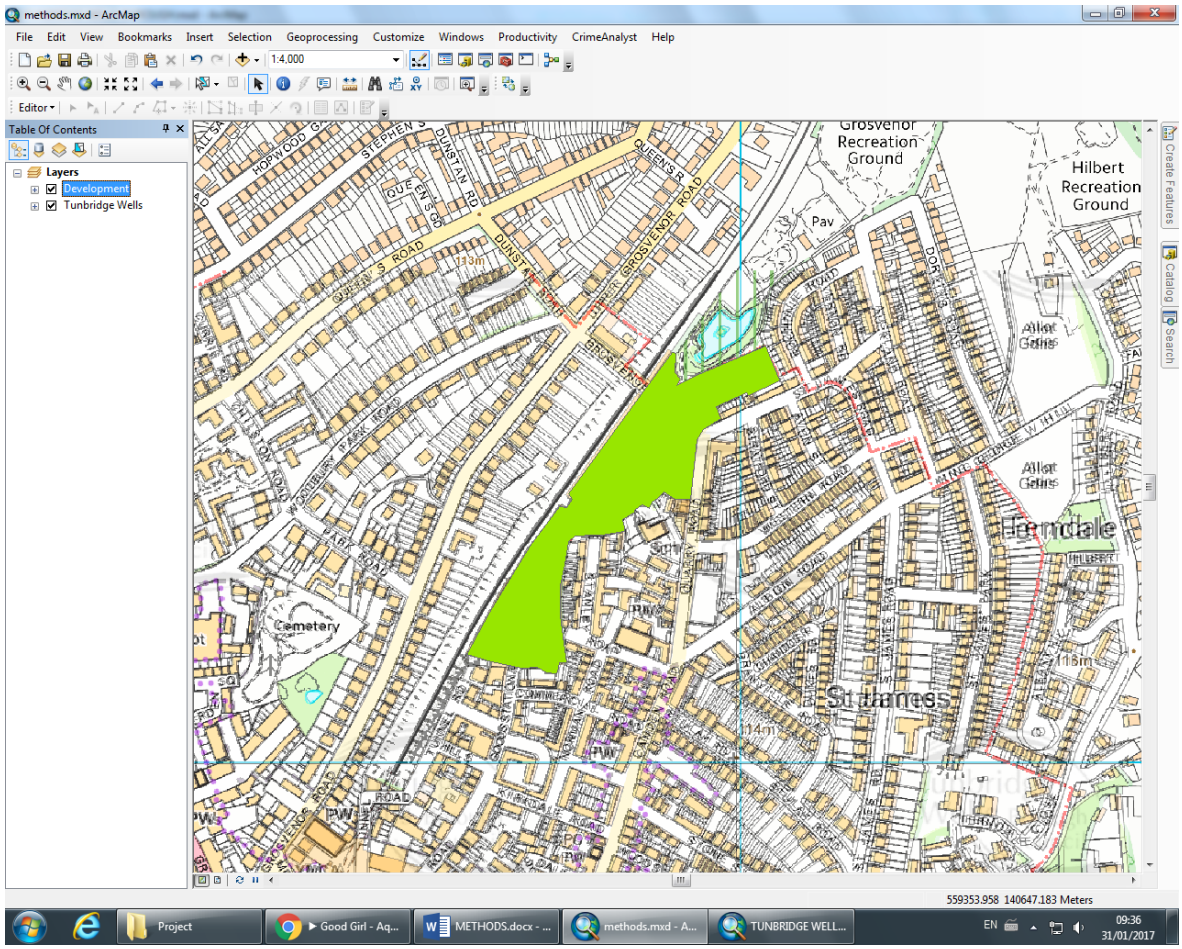

Figure 5 – screengrab of an area of Tunbridge Wells, with a polygon constructed to denote an area of land earmarked for redevelopment.

Once the screengrab was in situ, polygons were constructed around the areas identified as being allocated for development. These were drawn accurately with reference to the map underneath, which could be seen with the transparency of the overlay map set to 30-50% (see Figure 5). The polygon type drawn depended upon the land type, which was determined by making observations using Google Earth (Google. 2016 A) and Google Street View (Google. 2016 B), as seen in Figure 6.

The categories of land types on which the development occurs are as follows: aquatic (e.g. ponds, reservoirs), derelict land, woodland, redevelopment, agricultural land and recreational land. The land type of a development area may be identified using observations of a number of factors made using Google Earth (Google. 2016 A) and Google Street View (Google. 2016 B). For example, as Figure 6 shows, the large area of trees denoted with the yellow 'x' are clearly a wooded area. The colour and markings on the area marked with the pink 'x' show that it is an area of agricultural land, while the presence of houses show that development in the area marked with the green 'x' would be redevelopment. In some cases, it is not clear from Google Earth (Google. 2016 A) what the land type is. In these cases, Google Street View (Google. 2016 B) may be used and reference may be made to the 'Development Plan' documents in order to determine original land type.

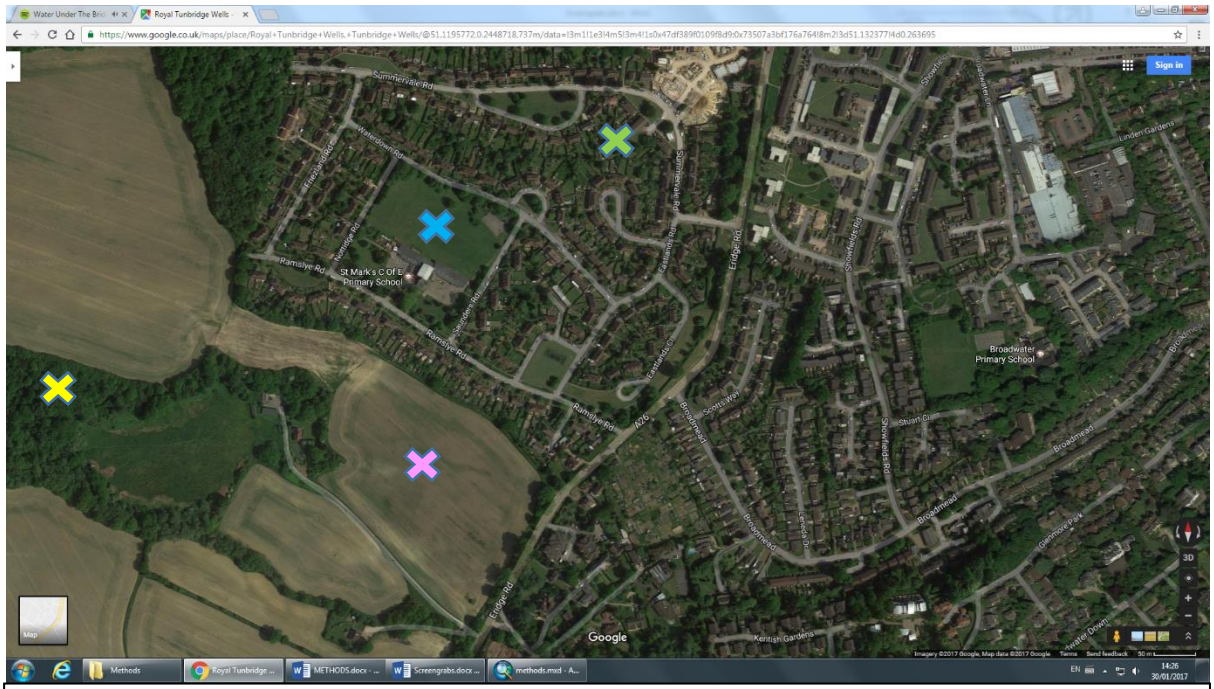

Figure 6 – screengrab of an area near Tunbridge Wells. Green = redevelopment, Blue = recreational, Pink = agricultural, Yellow = woodland.

In the case of each of Kent's 13 boroughs, a development plan was published by the Borough ouncil which was analysed in this way. Each borough was stored in the same ArcMap document; however, the suggestion for a larger scale project would be separate maps for each

borough due to the large size of mapping files used in the study. In addition, storage of the map was both on desktop and backed up on a secondary device such as a hard drive.

4.2. The effect of development set out in development plans on agricultural productivity

The total area of each polygon type was identified on ArcMap, and the total of these values was calculated. These areas were used in conjunction with datasets from DEFRA (Department for Environment, Food and Rural Affairs) (DEFRA. 2015 A) (DEFRA. 2015 B). Statistics made available by DEFRA included the outputs of various farm types in the South East of England, and the area of each farm type in the South East. The area of each farm type in the South East was used to calculate the percentage of the total farmed area, which was involved in the respective production type.

% farmed area = (area of farm type / total farmed area) x 100

It was assumed that the proportion of each farm type was consistent across Kent and the South East of England, which includes Sussex, Surrey, Hampshire, Berkshire, Oxfordshire, Buckinghamshire and Greater London. The climate of South East England is, for the purposes of this investigation assumed to be relatively consistent, and it is assumed that climatic variation between Kent and the South East as a whole will not have an effect on agricultural production. It is also assumed that no other differences between the South East and Kent will have an effect on productivity, such as the distribution of organic farms and soil type. Therefore, the percentages of farm types in the South East were used in conjunction with the area of agricultural land earmarked for development, as per the mapping area in ArcMap.

The value of production outputs per hectare land was calculated using productivity data from DEFRA (DEFRA. 2015 C). The outputs for each crop type in the whole of the South East of England were analysed, and the output per hectare calculated:

Value of outputs per ha = output of crop in South East overall (£) / area of crop in South East (ha)

The quantity of each crop area lost to development was analysed with the value of the outputs per hectare for that crop, in order to determine the total value of outputs lost for each crop per year in Kent due to the development.

In addition to this, the total yield loss was determined by the analysis of the yield of each crop per hectare, also available from DEFRA (DEFRA. 2015 B) and the Agriculture and Horticulture Development Board (AHDB) (AHDB. 2015). This was expressed as a percentage of the UK's yield. In addition, the percentage loss of output in monetary terms was calculated using DEFRA's data on UK total agricultural outputs.

4.3. The impact of future development on agriculture

Projections from Kent County Council (KCC. 2013) on the number of housing units required by 2031 were used in conjunction with data on the average plot size required for each house (UK Land Directory. 2004), in order to calculate the amount of land that would be acquired by 2031.

Data collected regarding total agricultural monetary output loss in Kent was analysed with the total land lost (of all types) to development. This gave a figure of agricultural loss per km^2 total land lost to development.

Predicted agricultural loss = number of houses x plot size x (agricultural loss/km^2 development)

5. Results

5.1. Land use change

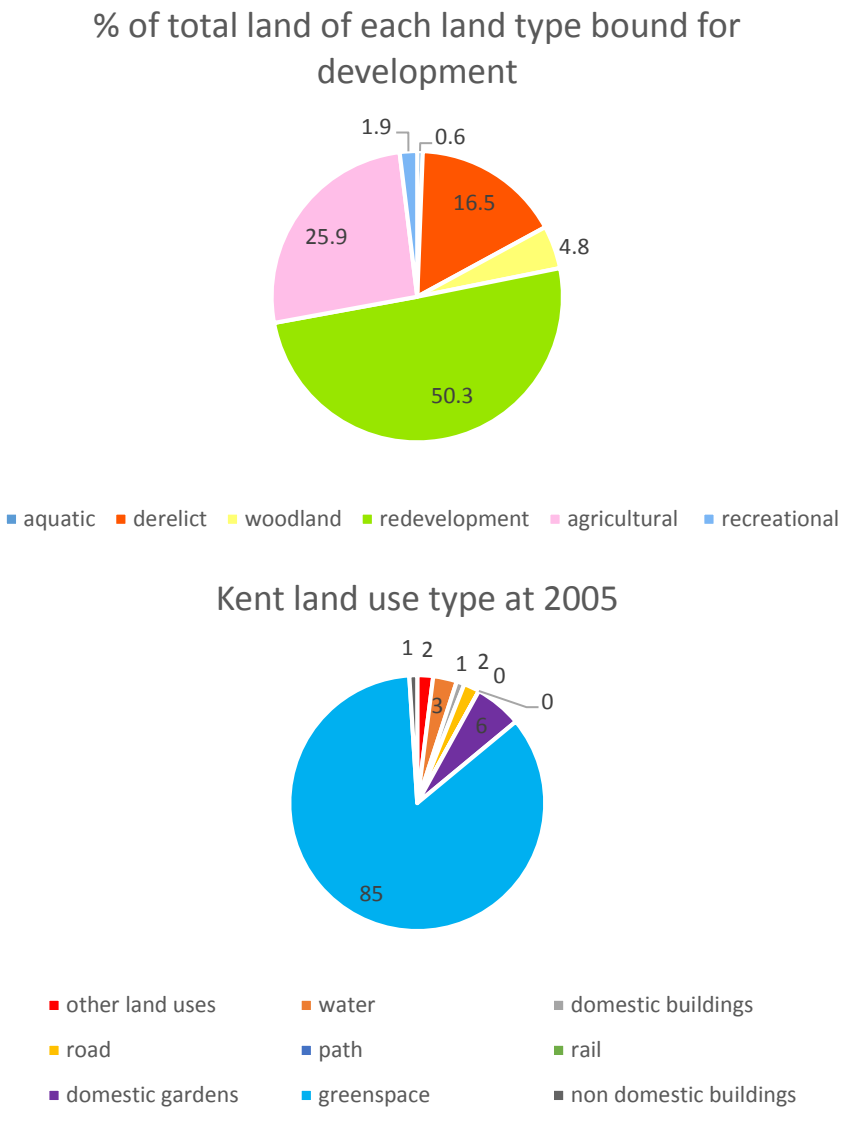

Figure 1: total area of each land type designated for development (ha), in comparison with a Kent County Council figure on land use in 2005 (KCC. 2005).

The land type representing the largest section of area bound for development is already developed; that is, the majority of each plot is already built upon (Figure 1). Redevelopment represents just over half of the development planned by the borough councils of Kent, while aquatic development represents the smallest section, just 0.6% of the total development planned across the county. Aquatic development was found generally within larger sections of other land types such as agricultural land, such as lakes or ponds within fields, as can be seen in Figure 2. As a comparison with the land use in Kent in 2005, there is a much larger area of redevelopment proportional to the overall land cover of domestic buildings (2% land cover in 2005, 50.3% development). Green space was shown, in 2005, to make up 85% of land cover; whereas in comparison, agriculture, woodland and recreational makes up approximately 33% of the land earmarked for current development. These figures show that the Kent County Council are not simply developing on all land types evenly; this may be due to the high demand for houses within and surrounding towns and cities, meaning development is generally on existing development or on derelict land.

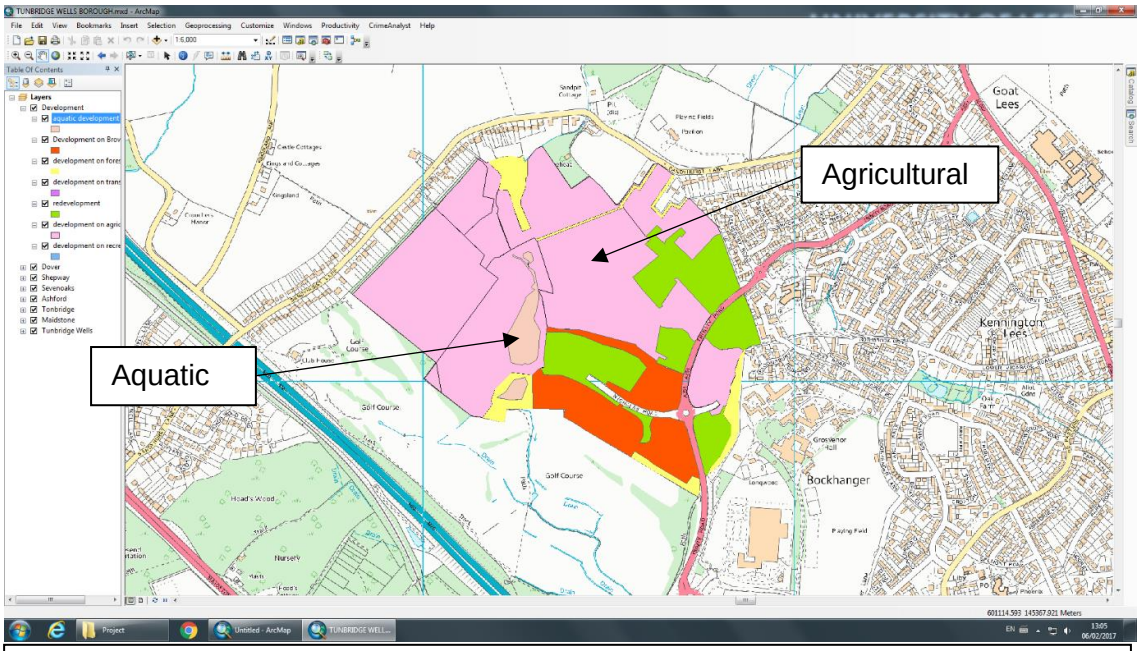

Figure 2: a mixed land use area bound for development within Ashford Borough

Also contributing a large portion of the land types being developed is derelict land, making up 16.47% of the land bound for development. Agricultural land makes up just over a quarter of land destined for development (Figure 1), with an average plot size of 8.31ha being removed from the agricultural sector for development purposes.

Development and agricultural productivity

Non-crop land makes up the largest proportion of agricultural land in the South East – 63.2% (Figure 3). This non-crop land consists of just under one half permanent grassland, almost

exactly the same area of 'other non-crop land', and 1.62% rough grazing land. The next largest proportion of agricultural land type in the South East is wheat, which represents just 18.36% of the total farmed area in the South East. The outputs for the 'non-crop land' (DEFRA. 2015 A) was assumed to be associated either with livestock, other agricultural activities, or inseparable non-agricultural activities, and it was the outputs from these industries that was used to represent the outputs for the non-crop land.

Farmland type	Thousand ha in SE	% SE farmed area	Outputs in SE (million £)
Wheat	222	18.4	265
Other cereal	108	8.9	71
Oilseed rape	86	7.1	101
Potatoes	3	0.3	14
Horticulture	27	2.2	396
Total non-crop land	765	63.2	918

Figure 3: annual outputs and value of production of farm types in the South East of England (DEFRA. 2015 A)

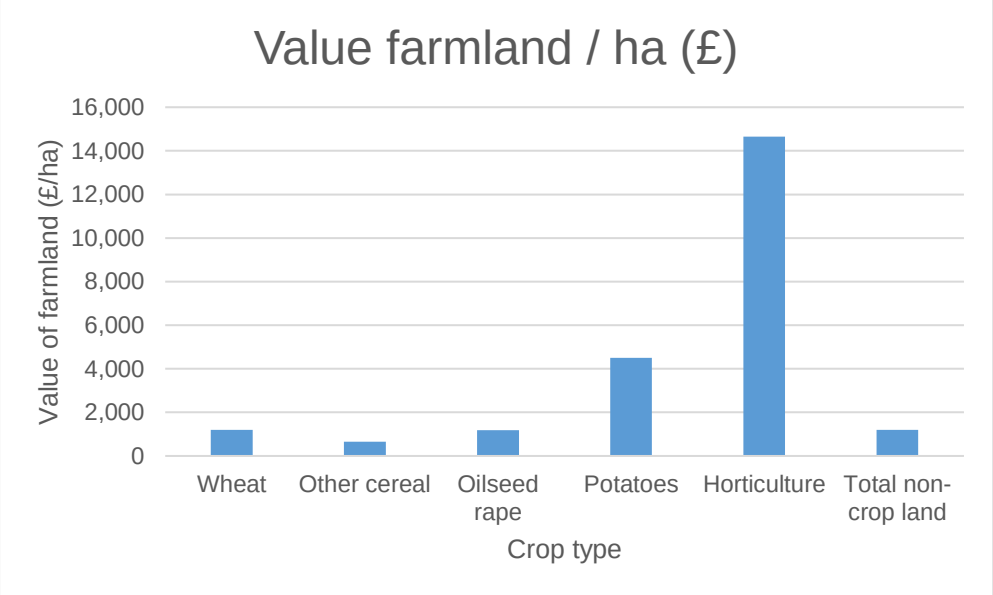

Figure 4: the value of farmland types in the South East of England based on output data from DEFRA (DEFRA. 2015 A)

Figure 4 shows the variation in value of each farmland type in the South East, data which was generalised to Kent, as production across the South East was expected to be relatively uniform. The production type with the largest value per hectare is the horticultural sector, despite it only making up 2.23% of the total farmed area of the South East. The value of land associated with wheat, oilseed rape and other cereals is all relatively low; in the South East

these fall between £660 and £1200 per hectare (DEFRA. 2016 B). This is between 4.51% and 8.14% of the value of horticultural land in the South East of England.

	% total area Kent agricultural development land	area bound for development (ha)	value / ha (£)	total value (£)
Wheat	18.4	143	1,192	170,820
Other cereal	8.9	69	660	45,774
Oilseed rape	7.1	55	1,181	65,108
Potatoes	0.3	2	4,509	9,154
Horticulture	27.0	211	14,645	3,092,014
Total non-crop land	63.2	493	1,199	591,855
				3,974,726

Figure 5: total value of land bound for development

The total value of the monetary loss to Kent's agricultural industry is estimated at just under £4 million (£3,975K), which is the sum of the monetary output lost in all sectors. This is shown in Figure 5, and represents 0.017% of the UK's total agricultural outputs. The largest contributor to this figure is horticulture, which makes up 77.79% of Kent's predicted agricultural losses.

	output (tonnes)/ha	total output loss (tonnes)	total UK production (tonnes)	% UK production lost
wheat	9.0	1290	16444000	0.0078
other cereal	8.0	555	8290000	0.0067
oilseed rape	3.9	215	2542000	0.0085
potatoes	44.7	91	5430000	0.0017

Figure 6: tonnage lost in each of four crop types, and as a percentage of total UK production for that

In some cases, information was available for the production in terms of tonnes of produce per hectare, as is represented in Figure 6. While data was not available from DEFRA for all crop types found in Kent, the information on crops such as wheat, oilseed rape and potatoes can be used to assess the impact of the loss of farmland in general. The crop which is predicted to have the largest impact on UK production due to loss of farmland in Kent is oilseed rape, but this figure remains low at 0.0085% of UK production (tonnes) of oilseed rape. Similarly, the loss of farmland is expected to result in losses of 0.007% for UK wheat crops, and 0.0067% for other cereal crops. The losses to the potato industry are lower still, with only 0.0017% of outputs expected to be lost.

5.3. The impact of future development on agriculture

Number of houses by 2031	158,500
Average plot size (km^2) (UK Land Directory. 2004)	0.001
Total land required by 2031 (km^2)	158.5
Total agricultural loss in 2003-2031 period (£)	3,974,725
Total land acquired in 2003-2031 period (km^2)	30.09
Agricultural loss/km^2 development (£)	132,094
Total predicted agricultural loss by 2031 (£)	20,936,989

Figure 7: calculations regarding agricultural loss as per predictions on development by Kent County Council (Kent County Council. 2013)

Long-term projections on population growth of Kent & Medway comes from the Kent County Council (Kent County Council. 2013). They suggest that by 2031, the population is likely to have risen by 17% from 2011, to 2,024,700. As Figure 8 illustrates, the need for additional housing is massive: 158,500 housing units are being planned for development across Kent by 2031.

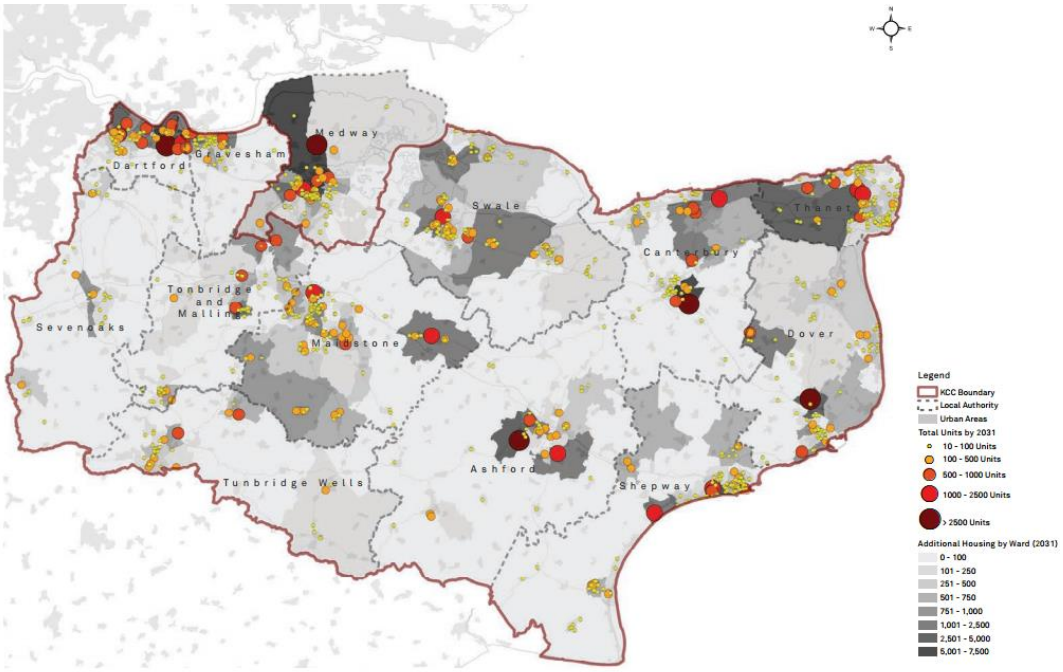

Figure 8: A map of Kent showing the predicted population growth in each borough, alongside the density of housing in areas in which it is planned (Kent County Council. 2013).

These additional housing units would require, if trends continued, an average of approximately 1 hectare per 10 houses (UK Land Directory. 2004). It can be predicted therefore, that 158,500 houses would require an additional 158.5km^2 land for their development. While the results of

the investigation found that approximately 30.09km^2 total land was earmarked for development over a period from 2003-2031; this is a larger area of land reserved for development compared to the previous 15 years. The agricultural loss per km^2 land lost is £132,094.57 per year, meaning that a 158.5km^2 loss of land (of any type) could equate to a loss of approximately £20,936,989 per year. The most recent figures from the Office for National Statistics (ONS. 2014) state the Gross Value Added of Kent's agriculture as being £226,000,000, therefore meaning that the building of 158,500 houses could lead to a 9.26% decrease in the value of Kent's agricultural sector.

6. Discussion

6.1. Future development

If the assumptions made in this study are to be depended upon, the effect of development in the next 14 years on agriculture in Kent could see monetary outputs significantly reduced. The development plans set out by borough councils, used in conjunction with data however, are not exhaustive sources of the development proposed for the county. In a number of cases, the development plans are out of date, which is one shortcoming of the method used. For example, plans are being proposed by developers for a community of 4,000 homes on the South side of Canterbury, building on land that is currently agricultural. These plans were not included within the latest Local Plan which was adopted in July 2006. While the time elapsed since the release of the most recent development plan may be the cause of the discrepancies between the development plan and those plans which materialise, proposals additional to those in the development plan should be considered. Their effect on the agricultural productivity of the region should also therefore be considered.

For every km^2 of land developed on in Kent, regardless of the land type, the average loss to the agricultural industry is £132,094 per year. While in many cases, the exact area of land planned for development is not disclosed by developers, there is evidence for a number of individual developments surrounding large towns in Kent (see Figure 1). It is also expected that many areas will be being surveyed for development, with little information regarding this currently available in the public domain.

Location	**Number of homes**	**Area of land (km^2)**	**Land Type**
Otterpool Park, Folkestone	12,000	>1.45	Farmland
Mountfield Park, Canterbury	4,000	2.27	Farmland

Graveney, Faversham	105	0.03	Brownfield
Strood, Medway	135	0.13	Farmland

Figure 1: information regarding a number of development sites currently being surveyed in Kent (Kent Online. 2017)

Long-term projections on population growth in Kent & Medway comes from the Kent County Council (Kent County Council. 2013). They suggest that between 2011 and 2031, the population is likely to have risen by 17%, to 2,024,700; the subsequent need for additional housing has led to 158,500 housing units being planned for development across Kent by 2031.

As shown previously, this level of development could lead to 9.26% decrease in the value of Kent's agriculture, and a 0.304% decrease in the UK's agriculture. While the latter of these figures appears inconsequential, it should be considered that Kent contributes only 3.46% (KCC. 2009) of UK agriculture's GVA, and that if the changes planned in Kent were found across the country, the effects on the UK's agriculture could be around a 10% decrease in GVA. This loss of agricultural land would likely have the effect of reducing the self-sufficiency of the UK; the strength of trade links would also be tested, as an increase in imports would be necessary in order to feed the population of the UK which is growing at 0.6% per year.

6.2. The future of food security in the UK

A 1.78% loss in GVA of agriculture in Kent in the last 10 years may not have had a noticeable impact on availability of food sources, for reasons including the availability of foreign imports. However, if, as predicted, the losses in the next 15 years rise to 9.26% of the GVA, the county may struggle to locate sufficient imports, especially if trends are followed in the rest of the UK. In the preceding 10 years, more than 1290 tonnes of the yearly potato yield are expected to have been lost, which is in keeping with figures for other crop losses. These losses will be much higher with the faster rate of development planned for the upcoming 15 years.

In order to keep up with the 0.6% population growth per year in the UK, food supply must also be constantly increasing. The UK is currently only approximately 60% self-sufficient in food production (Carrington, D. 2014), and to prevent this figure from continuing on its negative trend, the productivity of the UK must be increased overall. The constant acquisition of farmland for development, as demonstrated in this study, however, is unlikely to allow an increase in amount of productive land. Baulcombe et al defined a sustainable intensification (SI) system as one in which 'yields are increased without adverse environmental impacts and without the cultivation of more land' (Baulcombe, D. et al. 2009). The method of sustainable intensification would be suitable for a country with limited space for spatial growth of agricultural systems. There is an argument however, that sustainable intensification of agriculture is actually 'business as usual' (Franks, J. 2014), in that inputs are minimised and

outputs maximised in order to increase efficiency of the system. Increasing the productivity of the UK's systems is essential to maintain self-sufficiency with a growing population; due to the loss of agricultural land in the last 10 years, and the planned developments for the upcoming 15 years, an increase in output in remaining farmland will be required. An increase in UK agricultural productivity would likely be approached with a higher investment in research and development. Even if this were to increase yields, a halt in development on farmland would be required in order to allow the push for self-sufficiency.

The government stance on food security tends towards the opinion that self-sufficiency is not key to food security, stating in a 2016 release that 'achieving 100% self-sufficiency… would not insulate us from shocks to the system – for example, weather and disease can affect the harvest and yields' (DEFRA. 2016 A). While in the last 10 years it is unlikely that there has been little impact on food security in Kent due to development, there is a possibility that further development will damage the availability of food within the region significantly.

Government food strategy

The percentages yield loss in wheat, cereals, oilseed rape and potatoes in the 2003-2031 period are relatively low, at a <0.01% loss, and it can be expected that the effect on UK production due to losses to other crops will be similarly low. DEFRA cited the UK as 76% self-sufficient in the production of home-grown food (DEFRA. 2016 A), and in 2015, the then farm minister George Eustice pledged to reverse Britain's declining self-sufficiency in food under a new long-term agricultural strategy (Tasker, J. 2015). However, discrepancies can be seen between this pledge, and the long-term impacts of the acquisition of agricultural land in Kent and across the UK. While figures on Kent production loss should not be extrapolated to the UK, if the data were to be manipulated to show the same loss of production across the country, losses to the total monetary output of the UK's agriculture would be above 1%. However, due to the high demand for houses and therefore extensive development in the region (Fraser, I. 2016), it is clear that these data are not appropriate for extrapolation.

A decrease in the GVA of agriculture in Kent while undoubtedly have knock on effects on the more than 13,000 people employed in agriculture in the county (KCC. 2009). However, the government's plans to maintain a degree of reliance on imports instead of striving for self-sufficiency reduces the risk of the acquisition of land, and the consequential 9.26% decrease in the value of Kent's agriculture, to the availability of food to the public. The availability of food is key to the food security of a region, and providing there is no breakdown of trade links with European, South American and African countries, security may be maintained despite a decrease in agricultural productivity.

6.4. Food security schemes

While this study suggests that food security may be an increasing problem in the next few decades due to the loss of agricultural land, considerations should be made for other techniques to increase food security. A study published by the Food and Agriculture Organization of the United Nations (FAO) stated that around one third of human food produced each year is wasted (FAO. 2011); the impact of the loss of agricultural land may be lower if more is made of the food we have.

The Real Junk Food project is one of the schemes that has been set up in the UK in the battle to increase food security by minimising food waste. It has been suggested that if such schemes were successful and sufficiently wide reaching, they could decrease waste and potentially increase food security (Tielens, J. and Candel, J. 2014). An example of a project in Kent in order to reduce the wastage of food came from The Real Junk Food project, which lobbied for volunteers to help pick pears on a farm near Canterbury on 11th October 2015, to be donated to a number of food charities (The Real Junk Food Project – Edinburgh. 2015). The distribution of food from similar sources could provide a suitable option to reduce the pressure on the dwindling agricultural land in the United Kingdom.

In 2013, the then London Mayor Boris Johnson set out the FoodSave plan, which aimed to support small and medium sized businesses in minimising their food waste by distributing spare food to organizations that would redistribute the food, and directing waste to pigs where appropriate (London Assembly. 2013). While this will not eradicate food security problems in the UK, a further outreaching of similar schemes may significantly increase the ability of the country to feed its population.

6.5. Further impacts of development

This study also quantified the amount of other types of green space that were allocated for development; although the effect of these losses was not investigated, the loss of this land type should be considered important nonetheless. This study found that a total area of 58.36ha of recreational space was earmarked for development, and that 143.75ha of woodland was expected to be built upon in the 2003-2031 period. Not only this, but the 1512.64ha of land that will have been redeveloped will have undoubtedly had social impacts that are not currently understood. This leads to the suggestion that further studies are needed to quantify the social effects of the loss of green space.

Farmland, recreational land and woodland, and in some cases derelict land (brownfield sites) all provide habitats for a wide range of species (Kattwinkel, M. 2009). While this study has shown that losses in all of these land types will have occurred due to urbanisation, further

research into the effects of this loss on biodiversity will allow a more comprehensive view of the impacts of the loss of land to urban development on habitats, and therefore the impacts on biodiversity.

6.6. Evaluation

Although this project provides an insight into the effect that development will have on the productivity of agriculture in Kent, the data are not extrapolatable to other counties in the UK or to the UK as a whole due to regional variations in a number of factors such as productivity and development rate. Instead the data can be used as an example to the UK of the potential effects that could be seen if developmental rates are maintained.

Assumptions used in this project may have caused a skew of data; for example, the most area-specific data on productivity were used, but there are differences across the South East such as weather and soil types which may cause the data not to be completely true to the productivity found in Kent. The data on productivity in the South East also included London, which can be expected to have a skewing effect on data on productivity and land value.

Some of the development plans available are up to fifteen years old, such as Medway Borough Council's plan which was released in 2003. While the most up-to-date development maps were used in all cases, it is likely that some of the areas would no longer be an option for development; the opposite may also be the case, in that areas that were not initially considered as a development site have now been built upon. The age of the development maps may have caused issues when used in conjunction with Google Earth. Google Earth is updated according to satellites with a much higher frequency than development plan maps from borough councils are. This means that in some cases, land may be marked as a 'redevelopment' land type as it appears built up on Google Earth, even though it may have been a development built on agricultural land. This is because the development map outdates the Google Earth map, which may have caused the misrepresentation of the 'redevelopment' land type.

This study would be suitable for a larger-scale evaluation of the impacts of urbanisation on agriculture in the UK. Each borough council is required to provide a development plan, and provided up-to-date land use maps (such as Google Earth) are also available, as well as agricultural productivity data, further investigation could be undertaken. This is not simply restricted to the UK; the methodology used within this study could allow other countries to assess their agricultural productivity as well.

7. Conclusion

Urbanisation has been demonstrated across Kent in this study. While effects on the availability of food have not been demonstrated in this study, estimations have been made on the impact of urbanisation on Kentish agriculture and on the UK's agriculture.

The effects of urbanisation are expected to be more wide-ranging than those demonstrated in this study, and to quantify these effects, further studies need to be undertaken. This will give a more comprehensive assessment of the impacts of urbanisation. If a large-scale version of this investigation were to be undertaken across the UK, information gleaned could provide the government with an understanding of the long-term impacts of releasing agricultural land for development.

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