Uso de dados por horticultores de pequena escala no País de Gales: direções para o fornecimento de informação digital na administração rural

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Resumo: A segurança alimentar para pequenos agricultores exige práticas agrícolas resilientes. As fazendas são afetadas por fatores econômicos, de mercado, regulatórios e sociais, e o agricultor precisa receber informações relevantes, confiáveis e atualizadas sobre esses fatores. Um exemplo apresentado é o da horticultura no País de Gales, onde as propriedades de terra tendem a ser pequenas, com menos de 2 ha. A pesquisa demonstrou que os produtores têm um perfil etário predominante nas faixas mais antigas, de tal forma que as habilidades inter-gerações podem ser perdidas. O comércio é realizado principalmente por meio de vendas na fazenda, pontos de turismo locais ou varejistas locais. A maioria dos produtores tem acesso a tecnologias digitais. As mais úteis para o agricultor de pequena escala são os dispositivos de comunicação e as

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tecnologias de conhecimento que fornecem informações sobre preços de mercado, clima, condições do solo e melhores práticas. Essas informações aumentam seus benefícios e fornece cenários e modelos preditivos. Para usar as informações, os agricultores precisam de uma educação agrícola adequada. Os sistemas de conhecimento precisam ser desenvolvidos e mantidos, e isso geralmente requer o apoio do governo e das organizações de produtores. O uso das tecnologias do conhecimento e o fornecimento de informações bidirecional entre os agricultores e as Organizações de Produtores e Governo ajudarão a melhorar a produtividade das culturas, a sustentabilidade, a economia rural e o bem-estar das famílias.

Palavras-chave: Segurança Alimentar, Resiliência, Horticultura, Habilidades, Agricultura de Precisão.

Data use by small scale horticultural producers in Wales, U.K.: directions for the provision of digital information in rural management

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Abstract: Food security for small-scale farmers requires resilient farming practice. Farms are affected by economic, market, regulatory and social factors and the farmer needs to be provided with relevant, reliable and up-to date information on these factors. A case study is given of horticulture in Wales where land holdings tend to be small, being of less than 2ha. It showed the growers have an age profile predominating in the older ranges, such that inter-generational skills are likely to be lost. Trade is mainly through on-farm sales, local tourism outlets or local retailers. The majority of growers have access to digital technologies. The most useful to the small-scale farmer are communication devices and knowledge technologies supplying information including that on market prices, weather, soil conditions and best practice. This information increases its benefits if it provides scenarios and predictive models. To use the information, the farmers need an adequate agricultural education. The knowledge systems need to be developed and maintained and this often requires support from Government and Producer Organizations. Use of the knowledge technologies and the two-way supply of information between the farmers and the Producer Organizations and Government will help improve crop

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productivity, sustainability, rural economics and household well-being.

Keywords: Food Security, Resilience, Horticulture, Skills, Precision Agriculture.

Uso de datos por horticultores de pequeña escala en el País de Gales: direcciones para el suministro de información digital en la administración rural

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Resumen: La seguridad alimentaria para pequeños agricultores exige prácticas agrícolas resilientes. Las granjas son afectadas por factores económicos, de mercado, regulatorios y sociales, y el agricultor necesita recibir informaciones relevantes, confiables y actualizadas sobre esos factores. Un ejemplo presentado es el de la horticultura en el País de Gales, donde las propiedades de tierra tienden a ser pequeñas, con menos de 2 ha. La investigación demostró que los productores tienen un perfil de edad predominante en las franjas más antiguas, de modo que las habilidades intergeneracionales pueden perderse. El comercio se realiza principalmente a través de ventas en la granja, puntos de turismo locales o minoristas locales. La mayoría de los productores tienen acceso a tecnologías digitales. Las más útiles para el agricultor a pequeña escala son los dispositivos de comunicación y las tecnologías de conocimiento que proporcionan información sobre precios de mercado, clima, condiciones del suelo y mejores prácticas. Esta información aumenta sus beneficios y proporciona escenarios y modelos predictivos. Para utilizar la información, los agricultores

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necesitan una educación agrícola adecuada. Los sistemas de conocimiento necesitan ser desarrollados y mantenidos, y esto generalmente requiere el apoyo del gobierno y de las organizaciones de productores. El uso de las tecnologías del conocimiento y el suministro de información bidireccional entre los agricultores y las organizaciones de productores y gobierno, ayudarán a mejorar la productividad de los cultivos, la sostenibilidad, la economía rural y el bienestar de las familias.

Palabras clave: Seguridad Alimentaria, Seguridad Alimentaria, Resiliencia, Horticultura, Habilidades Intergeneracionales, Agricultura de Precisión.

1. Introduction

In order to be successful in providing livelihoods for the family, small-scale farmers require skills and continual access to information. The Competências Digitais para Agricultura Familiar (CoDAF) project has set its main goal "to minimize the factors that cause difficult access to information by small farmers, such as low familiarity with Information and Communication Technologies (ICT) and scatter availability of Information Systems (IS) specific to this public" (CoDAF, 2014).

This paper sets out a consideration of the priorities for family farmers in relation to the cropping of plants, in horticulture, arable or forest garden farms. The priorities described are those for which the farmer needs skills received either through formal education or by experience on the farm. To be achieved, these priorities require the regular input of information on markets, growing conditions or best practices. Both formal education and informal training, and the provision of information can be received through digital technologies. The scope of these technologies is described.

The current use of digital information by small-scale farmers is examined through a case study of horticultural growers in the United Kingdom's Principality of Wales.

Reflections are made on how family farmers can be prepared for the optimal use of information through digital technologies.

2. Food security for small-scale family farmers

There is not, as yet, an unambiguous definition for a smallholder (FAO, 2010) although it often relates to a land holding of less than 2 hectares. The characteristic of the family farm is that it supplies food to feed the family. Any surplus may be sold through markets. Traditionally this has been through local and wholesale markets but there is a shift away to vertical supply chains which may require contracts between the supplier and buyer. Family members may also take other employment to supplement their incomes, including seasonal work on other farms.

The Food and Agriculture Organization of the United Nations has given four main dimensions to food security for the family (FAO, 2008). These are: the physical availability of food which depends upon food production and net trade; economic and physical access which focuses upon incomes, prices and access to markets; food utilisation which determines the individual's nutritional status depending on the intra-household distribution of food and the diversity of the diet; stability which is determined by the continuity of the previous three dimensions over time. In order to measure these dimensions, the FAO recommends the use of indicators of food security

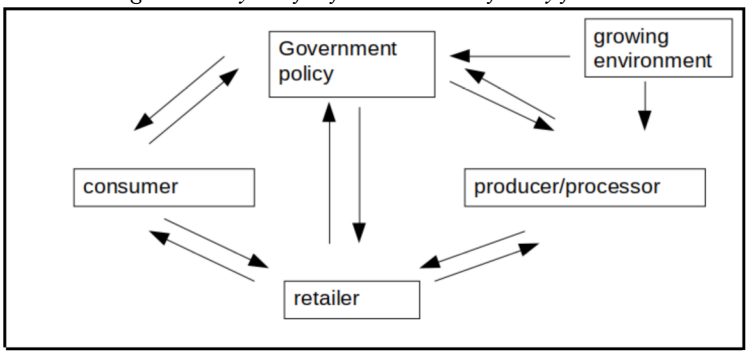
which include crude mortality rate, malnutrition prevalence, food access/availability, dietary diversity, water access and availability, household coping strategies and livelihood assets.

The household coping strategies are an indicator of the resilience of the family food production and livelihood systems. Both resistance and resilience to external pressures are crucial considerations in developing rural policies and recommending cultivation and marketing practices. Grimm and Wissel (1997) gave a definition of ecological resistance as the ability of a system to remain unchanged when challenged by disturbances. By contrast resilience has been defined as the capacity of a system to absorb disturbances and re-organize so as to return to the same function (Resilience Alliance, 2010). This means that the food system will be affected by external pressures but, when the pressures are relieved, it can return to its original productivity. However, there are tipping points, when resilience is exceeded, and it will be unlikely that a food system can return to its original state (Benton *et al.*, 2017). As family farmers are subject to a large variety of external pressures it is important, for their long term security, that their income and food systems are resilient. However, there are many components to these food systems and the effectiveness and resilience of each of these components need to be examined (Oliver *et al.*, 2018).

3. Factors affecting livelihoods

The factors that affect the livelihoods of family farmers should be examined, by those involved in the production of digital information applications, in order to set priorities in providing digital systems for these farmers. There are a number of actors in the production and sale of crops, these being the producer/processor, the retailer (who may be the producer if the crops are sold on the farm or directly in a market) and the consumer. These actors are further influenced by the growing environment and government policy. The interactions of the actors are shown in Figure 1.

Figure 1 – Cycle of influences on the family farmer



Source: Author.

For each of these actors there are economic, market, regulatory and social factors that determine crop production and sales and, so, livelihoods. These factors are categorised in Tables 1, 2, 3 and 4.

Table 1 – Factors affecting crop growth

Influence	**Factors**	**Contributory components**
Growing environment	Biotic	Pollinators and biodiversity
		Pests, diseases and risks to plant health
	Abiotic	Water quality and availability
		Climate type and stability
		Fertilizer use
		Use of chemicals for the control of pests and diseases
		Soil type, structure and condition
		Pollutants

Source: Author.

Table 2 – Factors affecting family farmers and their production and sale of crops

Influence	**Factors**	**Contributory components**
Producer /processor	Knowledge	Technical skills
		Access to knowledge
		Information sharing within business clusters
		Product development
		Waste management and reduction
	Markets	Competition
		Effective market size (customers – actual and potential)
		Provision of niche products
		Access to markets including fair and stable contracts
	Economic	Production capacity
		Energy cost and availability
		Fertilizer cost and availability
		Access to land, land tenure
		Cost and availability for the transport and distribution of goods
		Access to finance
		Cost of interest and exchange rates
		Seasonal cash flow
		Producer Organization support
		Taxation

Influence	Factors	Contributory components
	Government activity	Government financial and regulatory support
Retailer (may be same or separate from Producer)	Social	Family structure – ages, employment and livelihoods
	Knowledge	Labour skills needs and their provision Market trends Waste reduction and shelf life extension Transport and logistics Product positioning and development Sourcing (local, national, international) Stability of supply Contract maintenance

Source: Author.

Table 3 – Factors affecting the consumers of crops

Influence	Factors
Consumer	Access Availability Affordability Stability of supply Marketing and advertising influences Utilization

Source: Author.

Table 4 – Government policy affecting crop production and scale

Influence	Factors	Contributory components
Government policy	Financial	Import/export controls and tariffs Government agricultural support and intervention systems Taxation rules
	Regulations	Approved plant varieties and Plant Breeders' Rights/patents

	Packaging and waste regulations
	Plant health regulations
	Pesticide use regulations
	Fertilizer use regulations
	Planning and land use conditions
	Health and safety regulations
	Employment law
	Food safety regulations

Source: Author.

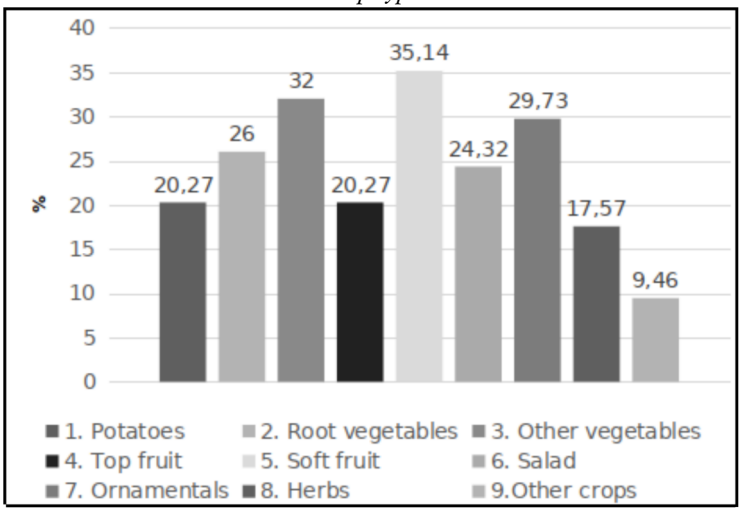
The farmer acquires the knowledge and skills necessary to farm and sell crops. However, once the skills have been developed, the farmer needs information to be supplied on a continual basis in order to produce and market crops and to derive income in an ever-changing economy. The farmer can then be proactive in crop choice and marketing and can optimise productivity and profitability and be resilient as conditions change. Each of the factors can be investigated independently for the development of appropriate, digital, information sources for both the growers and retailers. The priorities for family farmers, deduced from these factors, is summarised in Table 5. Sustainability and resilience has to be embedded in each of these priorities.

4. Characteristics of digital information use in Wales.

Wales is a Principality of the United Kingdom (U.K.). The latest, 2017, population estimate was 3,125,200 people (Office of

National Statistics, 2018). Its physical geography is of a central mountainous region with the majority of the people living on the coast and the southern valleys. It has an eastern border with England which is a more populous country. Much of the trade in horticulture is either local to the grower or with the English cities. Major road networks are around the coast or the border with England and the main road routes from North to South require travel into England. Horticulture in Wales uses 1599ha of land and retail sales in Wales amount to £807m (Food and Drink Wales, 2017). Policy for agriculture is devolved to the Welsh Government from the U.K. Government.

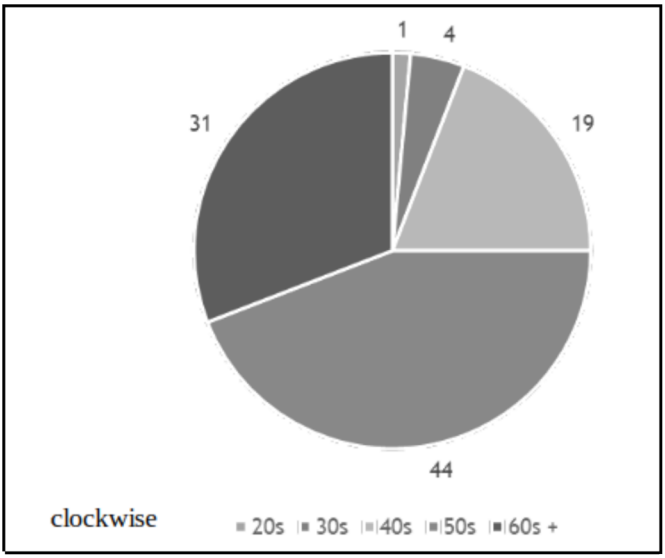
Figure 2 – Percentage of surveyed smallholders in Wales growing each crop type



Source: Author.

A survey of grower businesses in Wales was conducted in 2015 from a database of businesses that had engaged with the project "Horticulture Wales". This database was representative of the variety of commercial horticultural enterprises in Wales as it consisted of the majority of active horticultural producers. Seventy-four businesses responded which comprised 1564 workers of whom two thirds were seasonal workers (67%). The survey showed that a range of edible horticultural crops were grown including salad crops, potatoes and other root vegetables, herbs and fruit as well as ornamental crops such as plants for decorative gardens or cut flowers (Figure 2).

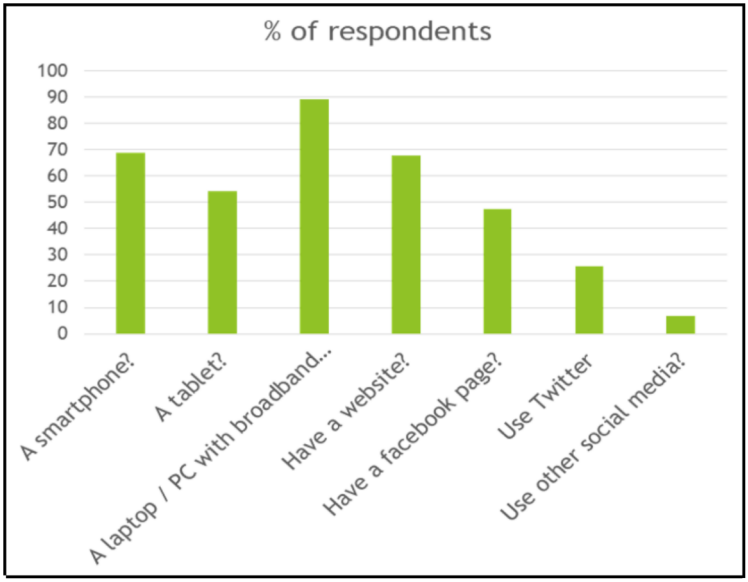
Figure 3 – Age of respondents to survey in Wales



Source: Author.

Whilst farms growing potatoes tend to be larger in hectarage, the horticultural sector in Wales is characterised by small holdings of less than 2 hectares. Respondents were predominantly aged over 50 (75%) (Figure 3). This age profile is significant as it means that many of the workers will retire soon and experience and skills will be lost. Furthermore, these workers will not have received training at school in the use of digital technologies.

Figure 4 – Percentage of respondents in Wales using surveyed methods of digital communication

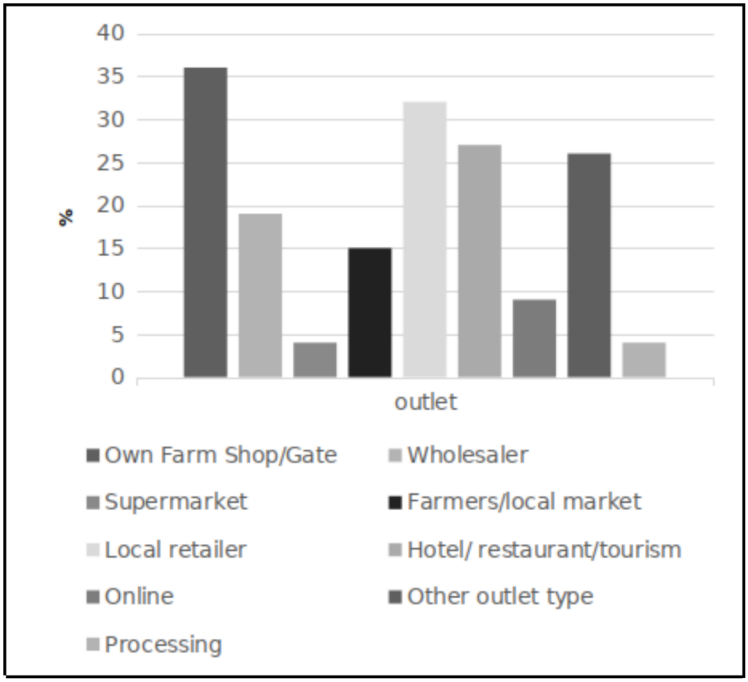


Source: Author.

The enterprises were surveyed on their use of digital technologies (Figure 4). It is noted that the majority of the

respondents did have access to a computer with a broadband Internet connection, but not all the businesses had this facility. Two-thirds of businesses had a website which means that one third of the businesses were not attracting customers or conducting commerce through this medium. Also, the use of communication and advertising through social media was low with only half of the businesses having a Facebook page.

Figure 5 – Percentage of respondents in Wales using surveyed retail outlets



Source: Author.

Whether there is a need for using these digital communication methods for conducting business is shown in the sales outlets that the enterprises used (Figure 5).

The largest amount of trade for the growers was through their own farm shop or simply selling produce at the farm gate. Many businesses traded with a neighbouring retailer or supplied food to restaurants and hotels in their area. Other produce was sold to local wholesalers who, in turn, would then sell through city markets. All this trade usually operates through personal contacts and there is not a requirement for advertising through digital media. However, if such media are available then transactions costs can be minimized through customers checking product availability or ordering online. Other trade was to multiple retail chain supermarkets, and to processors. In these cases, sales are more competitive and the customers do not need to source produce locally. Contracts are issued by the purchaser to those growers who have been successful in their sales to the buyer. For these types of business relationships, an online presence for advertising and for immediate, documented communication is near essential. Some of the enterprises did operate business trading online. These transactions tend to be for processed products e.g. jams, or for ornamental plants or young trees and are often for sales made directly to individual consumers.

These results demonstrate that many of these businesses can be contacted through digital media and would be able to receive information in this way. As broadband and mobile phone coverage expands in Wales more farmers will be able to use digital media and this will be further encouraged by Government increasing their requirement that statutory document returns from farms should be made via the Internet. It must be remembered, though, it was shown that not all farmers will have access to the information from these media, whether because of the lack of broadband or mobile phone coverage or because of not having digital media skills. Those famers will then be socially excluded from competing commercially through these tools.

5. Digital solutions for farmers

Digital solutions for farmers are encompassed by the term Precision Agriculture. A widely accepted definition of this is "a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production" which will have a significant impact on the spatial and temporal improvement in crop productivity (National Research Council, 1997). The components of this strategy are considered to be the capture of appropriate data, the analysis and interpretation of the data, and the implementation of a useful management response to the

information. So, it is the use of information technologies, and the ability to provide data, highly resolved both in time and spatially, which provide the essential difference between conventional and precision agriculture.

The range of digital solutions that can be made available to farmers, supplying up-to-date information, can be categorised into two groups i.e. as on-farm production technology or as knowledge technology (including communication devices).

The on-farm production technology includes crop sensors in the field which may be used to monitor soil factors such as nutrient status, water levels or soil compaction. Sensors can also be utilised to monitor crop characteristics including biomass, crop health and the presence of pests or diseases. Increasing use is also being made of Global Positioning Systems (GPS) and satellite imagery for viewing crops on field or on farm scales so that decision making is enhanced in relation to the husbandry of the crops. The technology is currently being extended through the use of Unmanned Aerial Vehicles (drones) carrying cameras. These can be operated directly on the farm. Both drones and GPS are being used in conjunction with remote-controlled, robotic vehicles in the field for precision cultivation in planting, weeding and harvesting (Bechar & Vigneault, 2017). However, the equipment needed for these technologies in both cultivation and in crop processing is expensive and is most

relevant to large farms. It is less appropriate to small-scale farmers for whom it may not be economically viable to invest a large amount of capital in such equipment. The use of this equipment may also have a negative impact on rural employment which would not be desirable in some regions.

In contrast, the knowledge technology can be made available, from a remote provider, to any farmer who has access to a mobile phone or the Internet. The farmer must, though, have the skills to be able to interpret and utilise the information from these technologies. There are a range of applications that can be produced for the farmer. These may provide financial data on credit interest rates or exchange rates or on markets such as regional or global, sales prices rates. They may also provide the farmer with weather data or they may simply be information sources, for instance, on best practice in crop selection, nutrition and husbandry. Communication between farmers for trade or support is encouraged by mobile devices and social networking applications. Loiola & Fonseca (2015) stated that a lack of communication between producers and buyers has impacts both on the correct quality of goods being supplied and the financial performance of both parties.

Digital information sources can be enhanced by the provider through using the data to produce models which can give predictions or forecasts for different scenarios. The farmers'

decision-making is then better informed. Examples include disease early-warning systems and crop yield predictors. Comprehensive modelling and information services for farmers requires the collection and input of a large amount of global and regional data on crop production, geographical variables such as topography, climate and soil types, market prices and trading, and economic and social outcome data such as household characteristics (Capallo *et al.*, 2017). This Big Data and the resultant statistics may also be used by policy makers.

6. Delivering digital solutions

Digital technologies are available for the delivery of knowledge systems to family farms. However, the production and maintenance of systems and applications depends upon the willingness of governments or corporations to provide them, and their use depends on the farmer's access to them.

The farmer needs a data connection to the knowledge application either through a computer or a smart phone. Lizzoni *et al.* (2018) surveyed 20 farmers in Oeste Paranaense in Brazil and found that all were connected to the Internet. In Wales (Figure 4) not all growers were connected but occasional access can be made by them through local, community-provided, book libraries. Such high levels of connectivity will not be available globally, to all rural regions and subsistence farmers, but access is widening continually.

With such opportunities available for farming efficiency to be improved through digital applications it is important that appropriate applications are developed. This may require substantial resources particularly where large and complex data sets have to be used. The systems using Big Data should be designed to understand the complex interactions of factors (National Research Council, 1997). This may be done by commercial corporations but they will expect a return on their investments and so these systems are likely to be available predominantly only through a financial subscription by the user. This may put such systems out of the reach of the family farmer. Alternatively, the systems may be produced by governmental or academic/research organizations and offered free to the user thereby providing a social benefit.

Such systems will require the frequent input of reliable data on productivity, farm structures and employment and environmental quality. The data will need to come from a variety of sources including the farmers themselves and government agencies. When the data has been collected from a number of contributors the issue of who owns the Intellectual Property Rights emerges and so such systems operate more satisfactorily where information, both input and output, is given freely and by mutual consent. Aleixo *et al.* (2016) have noted that many rural extension services do not yet include

support for Information Technology systems. Policies that encourage government and academic co-ordination within such extension services, to integrate these systems into their delivery, would be beneficial.

There are also current and potential developments for a wide range of knowledge applications that do not require Big Data. They may provide advice or may utilize more local information. Piccolo & Affonso (2017) have described how the ability to price their produce correctly is very important to small-scale producers, and they identified 21 websites that provided crop pricing information in Portuguese.

It is for these applications, that provide more local information, that Producer Organizations (PO) may have roles. These will be in either developing and maintaining the applications or in encouraging systems developers to do so, and in urging network providers to make them available. Deponti *et al.* (2017) noted that understanding the everyday life of the farmer should be the starting point for the development of a useful application. POs are collectives of, most often, small-scale farmers and may take different forms, including co-operatives (Skydmore, 2018). The main functions of POs are collective marketing, financial advice to their members, provision or arrangement of credit, management of equipment, and social welfare through access to health and education.

These functions are carried out to varying extents, depending upon the complexity and expertise of the organization. Through the collective action of the farmers the POs are able to provide affordable services that would not be available through an individual, family farmer's resources. The PO represents and defends the interests of its members. For example, a PO can mediate in supply chain transactions for its members. It can also be an advocate in property rights.

The PO, or other type of organization, needs to encourage the development of the application, then promote its adoption by farmers in order to improve farm efficiency. It must then continue to support the application through the regular supply of data. All this will require long-term enthusiasm for the digital technology from the organization. The key factor in this will be to have people who will lead and champion this resource. These people will need to be aware of rural strategy, and be excellent communicators, in order to promote awareness of the application.

Ffowcs-Williams (2000) has stressed the need for a planned and structured approach to activities in business clusters such as POs. He described 4 developmental stages. The first is to carry out research. In the context of the knowledge application this would include determining the purpose of the application and its priorities, and finding reliable and sufficient data sources.

Secondly, the people to develop and manage the application must be chosen. Without capable, committed and enthusiastic people to champion the project, it is unlikely to succeed, particularly in the long term. The third stage is to complete the actual development of the application and the collection of the initial data. Fourthly, an organization must be formed, or embedded within an existing organization, so that the data can be collected and entered regularly, its reliability checked, system and model updates made, and the system sustained.

In Wales there is a wide variety of information available online to farmers, produced and funded from a number of sources. For example there are Government websites on regulations and subsidies[1]; weather forecasting and information on average seasonal conditions, targeted at agriculture, is available through the government-funded agency the Meteorological Office[2]; detailed maps of soil types which can be resolved for individual farms is provided by the British Geological Survey[3]; the Agriculture and Horticulture Development Board, funded by a levy on larger scale farmers gives information including market prices for cereals and oilseeds, plant pest and disease identification for a wide range of

1 Available at https://www.gov.uk. Accessed on Dec 19th, 2018.

2 Available at https://www.metoffice.gov.uk/services/agriculture. Accessed on Dec 19th, 2018.

3 Available at https://www.bgs.ac.uk/mysoil. Accessed on Dec 19th, 2018.

crops, and the results of the latest research undertaken at the request of growers. Lists of recommended varieties can be found from a number of sources with the National Institute of Agricultural Botany supplying the National Lists. These give the varieties which are eligible for certification and marketing in the |U.K. after field trials have shown their benefits for cultivation and use[4].

However, all these digital resources require the education of the farmer so that they are able to interpret the data. Online training videos are available for agriculture and horticulture but again the farmer must know what to look for in order to find them and so education is required.

In conclusion, there is an enormous potential for the use of digital, online and mobile application resources for farmers. Connectivity is already good, and increasing. There is a large amount of data available but this must be developed further into usable resources which include demonstrations of best practice and predictive models. The availability of accessible information, which can be used by a knowledgeable farming community, will have considerable beneficial effects on improving crop yields and quality. There is also a significant opportunity for the farmers to supply information back to government and agencies so that rural policies can be informed

4 Available at http://www.niab.com. Accessed on Dec 19th, 2018.

by evidence and then provide improvements to farm structures and household incomes and to optimize rural employment.

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