Development of an online decision support aid to facilitate progression of Irish sustainable communities

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

Development of an online decision support aid to facilitate progression of Irish sustainable communities

Anne Bennett B.Sc

Centre for Environmental Research,
Department of Chemical Sciences,
School of Natural Sciences

This thesis is submitted in accordance with the academic requirements for the

Degree of Master of Science

Supervisor: Dr. Bernadette O'Regan

Submitted to the University of Limerick: May 2019

Declaration

I declare that this thesis has not been already accepted in substance for any degree and is not being submitted in candidature for any degree.

I affirm that the substance of this thesis is entirely the result of my own investigation and that due reference and acknowledgement is made where necessary to the work of other researchers.

_____

Anne Bennett

Date:_____

Acknowledgements

This project has been made possible by the direct funding of the Environmental Protection Agency Ireland and the invaluable guidance provided by Dr. Bernadette O'Regan and Prof. Richard Moles. Your support and encouragement over the period of this research has been very much appreciated and has given me a new set of skills and understanding I otherwise would not have acquired.

A special thank you to Susan and my partner in crime, Rosie, for your continued reassurance, encouragement, advice, friendship and general chats and laughter over tea and cake when it was most needed.

To my wonderful family and friends who have supported me throughout this process, especially in the final months of writing. I am so very grateful for your words of encouragement, the brief breaks from reality you provided, for checking in to see how I was and of course the continued support in the form of chocolate!

Thank you to my friends and fellow researchers Gemma, Rachel and Will. The chats and rants over tea breaks, lunchtime and fitness classes will not be forgotten! It has been a journey.

Lastly, thank you to my boyfriend James. Your continual positivity and encouragement have always been so important and appreciated, especially over the past two years.

Abstract

Climate change, increasing consumption of resources and dependence on fossil fuels pose significant risks to communities, nations and the world as a whole. Sustainable development has long been recognised as a strategy to counteract these negative impacts. Previous studies have stressed the need to involve voluntary communities at local level, in implementation of successful sustainable development programmes, in order to achieve national and EU targets for reduction of Greenhouse Gas (GHG) emissions. Within the context of EU countries, Ireland has one of the poorest records for GHG reduction and increased renewable energy strategies, therefore urgent improvement is necessary to meet environmental policy targets.

This project focused on the promotion of sustainable communities at an Irish local level. Through review of literature and building on previous work carried out in the Centre of Environmental Research in UL, several key barriers to progression of sustainable communities were identified. These included a deficiency in the provision of technical, legal and financial content at the local level, thereby preventing communities from sourcing information on setting up legal organisations and obtaining funding. The objective of this project was to bridge the pre-determined knowledge gap by disseminating the identified information at the local level in an accessible and user-friendly manner. Critical review of existing web aids and comparative analysis on development platforms provided a strong case for the construction of an accessible web based Decision Support Aid (DSA). For the purpose of this project, a web based DSA is described as an information tool in the form of a website, which guides users through decision stages, providing them with information, so that they can make an informed decision at the end of the process. The web based DSA was developed using a tailored Web Development Life Cycle methodology and employment of WordPress.com and WordPress.org. The prototype was evaluated and modified based on feedback to deliver the finalised version. Evaluation suggested that the web based DSA possessed the potential to act as an enabler towards local level sustainable action in Ireland.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BSI	British Standards Institute
CARES	Community and Renewable Energy Scheme
CER	Centre of Environmental Research
CMS	Content Management System
CSS	Cascading Style Sheet
DCCAE	Department of Communications, Climate Action and the Environment
DCENR	Department of Communications, Energy and Natural Resources
DSA	Decision Support Aid
DSS	Decision Support System
DST	Decision Support Tool
EDSS	Environmental Decision Support System
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
HTML	Hypertext Markup Language
IIED	International Institute for Environment and Development
PHP	Hypertext Preprocessor
SD	Sustainable Development
UN	United Nations
VOiCE	Visioning Outcomes in Community Energy
WP	WordPress

1 Introduction

This research presents the development of an online environmental decision support aid aimed at Irish communities to aid the progression of sustainable actions at the local level. The research examines the concept of sustainable development, the barriers associated with sustainable community advancement and determines the optimal solution to disseminate information to the local level in order to fill the knowledge gap.

The introduction sets the scene for the project by presenting context of study, sustainable development as it relates to Ireland, the importance of sustainable community initiatives in lowering carbon emissions and the research aims and objectives.

1.1 Context of Study

The concept of sustainable development has long been recognised as the solution to harmonising human society and natural systems to overcome the destructive environmental and social impacts of the prevailing approach to economic growth (Simonovic 1996; Zeng *et al.* 2003). The increasing consumption of resources, growing dependence on fossil fuels, food shortages and population growth pose extravagant risks to communities, nations and the world. It is clear that a thriving economy is accompanied by unintended consequences, evidenced by climate change, water pollution, air pollution, a diminishing ozone layer and loss of biological diversity. The urgent need to enhance sustainable development is evident.

In 1987 the Brundtland Commission introduced the term sustainable development as '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*' (WCED 1987). Since then, it has been coined under various definitions creating a sense of complexity and ambiguity. However, Brundtland's definition remains the global standard which underpins most interpretations. The report received criticism but it did succeed by highlighting the links among economic development, social justice and environmental protection, in addition to prompting numerous political actions such as Agenda 21, Rio Declaration, Kyoto Protocol and Paris Agreement.

1.2 Sustainable Development in Ireland

Addressing sustainability is a major concern in Ireland. The economic pillar of sustainability was prioritised during the Celtic Tiger (1997-2007) resulting in industrialisation and urbanisation. Urbanisation refers to the movement of population from rural to urban areas enabling cities to expand (McGranahan and Satterthwaite 2014). There is no standard international definition for urban areas as each country interpreters it differently based on population size, population density, economic activity, level of infrastructure or physical characteristics. While the economy strives, development becomes more fragmented and distances increase between homes and amenities resulting in over consumption of natural resources and increase in greenhouse gas (GHG) emissions. It is widely acknowledged that Ireland will fail to meet its 20% reduction of 2005 GHG emission levels for 2020 targets (EPA 2018). The Paris Agreement sets Europe a target of 40% reduction of EU wide emissions by 2030 (UN 2015a). At the current rate Ireland will struggle to achieve their contribution.

The progress towards sustainable development is linked with the integration of social, economic, political and ecological processes at all levels from local to global (O'Regan *et al.* 2002). The urban transition can be seen as an opportunity for environmental, social and economic advances which could aid Ireland in meeting its policy goals, if steered in the right direction. Response to the recession (2008-2013) also focused on the economy, banking system and austerity measures while the global concerns of peak oil and climate change were side-lined. As the Irish economy recovers, the separation of economic growth from environmental impact is yet to be achieved with GHG emissions increasing and consumerism rising (ERSI 2017). The development of sustainable communities is seen as a method to counteract these challenges by:

1. Managing natural resources through waste schemes and renewable energy.
2. Circulating money within the community by local farming.
3. Ensuring social development through renovating community halls and conducting local events.

1.2.1 Sustainable Communities

While the concept of sustainability has different meanings dependent on the community, it reflects a growing concern of urban, rural and city establishments to be aware and proactive about their environment, resources and impact on climate. It focuses on building resilience

in order for communities to possess the ability to not collapse at first sight of oil or food shortages. Resilience refers to being more self-reliant and prioritising the local over the imported (Hopkins 2008). Community based projects play a significant role in promoting the ideals of sustainable development at the local level (Carragher 2011). These sustainability transitions have been implemented, on a global scale, from bottom up approaches to combat climate change, ecological degradation, economic decline and public health issues (Forrest and Wiek 2014). International success of bottom up initiatives, including sustainable energy communities and local food hubs, have been seen throughout Sweden (Gardner 2011), Scotland (Ross 2018), England (Franklin *et al.* 2011) and Germany (Romero-Rubio and de Andrés Díaz 2015). This international experience suggests major socio-economic and environmental gains may be achieved through local level action. Community led initiatives possess the ability to engage and empower local members and stakeholders in a way that top-down initiatives cannot, as they consider the inner workings of the specific community involved (Charnock 2007; Seyfang and Smith 2007; Forrest and Wiek 2014). They have the potential to reduce Greenhouse Gas (GHG) emissions through uptake of renewable energy, energy efficient housing and public building design concepts, reuse of existing infrastructure, preservation of open green space and reduced car dependency (Moles *et al.* 2006; Seyfang 2010). While sustainable development has long been a dominant principle in policy development (Fahy and O'Cinneide 2008), the importance of citizen engagement is only recently being realised at National level. The White Paper *'Ireland's Transition to a Low Carbon Energy Future 2015-2030'*, sets out a framework to guide policy and government actions in the energy sector up to 2030. The paper is unique in that it recognises the importance of citizen engagement, stating, '*there will be a new focus on citizens and communities as active participants, and agents of change*' (DCENR 2015). Evidently a greater emphasis needs to be placed on bottom up initiatives in Ireland's transition to a low carbon society.

1.3 Research Aims and Objectives

The aim of this research was to develop a decision support aid, which facilitates the progression of Irish sustainable communities, through knowledge transfer. In order to achieve this aim, several key objectives were established. These include:

- Investigate the barriers to progression of sustainable communities through literature review.
- Investigate existing environmental and sustainability web aids using an assessment framework, to determine the knowledge gap in provision of online information.
- Determine DSA goals based on the identified knowledge gap.
- Identify target audience of the DSA.
- Gather relevant content based on literature review of barriers associated with the progression of sustainable communities.
- Review user-centred design strategies to format content.
- Determine most appropriate platform for development of DSA and deployment of information based on DSA goals, target audience and content.
- Develop DSA using theory driven methodology.
- Evaluate DSA with cooperating communities and project Steering Committee.
- Modify DSA based on evaluation feedback and finalise.

2 Review of Literature

Review of literature was divided into two dominant sections; Sustainable Development and Decision Support Technology. The purpose of this chapter was to build an understanding of the barriers associated with the uptake of sustainable communities at the local level and identify the most suitable method to disseminate relevant information to the general public, in order to aid progression of sustainable communities and fill the determined knowledge gap. This was achieved through review of the concept of sustainable development from different perspectives, researching climate policy that drives sustainable development and reviewing predefined issues associated with progression of sustainable communities. Secondly it was imperative to investigate decision support technology as a means of disseminating information to the local level. This was executed through analysis of Decision Support Systems (DSSs) with emphasis on environmental DSS and limitations of traditional DSS. Furthermore, several comparative analyses were conducted to identify a suitable alternative to traditional DSS and an appropriate development platform. Further research was carried out on web based platforms and existing environmental and sustainability web aids to determine the knowledge gap in the provision of online information and how best to address it.

2.1 Sustainable Development

The concept of sustainable development (SD) has attracted significant attention from various backgrounds including researchers, governments and international environmental organisations (Midin *et al.* 2016). Joseph (2013) states '*it is becoming increasingly difficult to ignore the concept of sustainable development*'. It is indeed a global issue, with Hsieh (2012) affirming that, '*the need for sustainability has assumed an increasing importance on the environmental agendas of nations around the world*'.

The environmental movement was first brought to the public's attention by Rachel Carson in 1962 through her book '*Silent Spring*' (Carson and Darling 1962). It is considered to be the '*wakeup call for environmental issues*' as she discusses the negative impacts of pesticides on nature. Environmental organisations such as green peace and fields of the earth were founded in 1971, and there was a report published by Club of Rome titled '*Limits to Growth*'. In 1983 the World Commission on Environment and Development was created with the purpose of identifying a new strategy that incorporated environmental and development issues. It was not until 1987 when the Brundtland Commission published its

report, '*Our Common Future*', that the term sustainable development was introduced as a remedy to the current economic model. Since then, it has been coined under various definitions creating a sense of complexity and ambiguity. However Brundtland's definition remains the global standard which underlies most interpretations:

> *'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987).*

The definition addresses environmental issues, while also focusing on social and economic implications (Berglund *et al.* 2014). The report received criticism however it did succeed by highlighting the links among economic development, social justice and environmental protection, in addition to prompting numerous political actions including Agenda 21, Rio Declaration, Kyoto Protocol and the Paris Agreement (Johnson 1992; UN 2015a). In literature, there are many interpretations of concepts relating to sustainable development, each offering a distinguished contribution to its broad definition (Lindsey 2011). However with varied explanations comes a sense of complexity and dichotomy, with some authors branding the concept as vague, ambiguous and a breeding ground for disagreement (Pearce *et al.* 1989; Brandon 1999; Mazloomi and Hassan 2008). Similar to the Brundtland definition, SD is often perceived as a combined concept made up of three pillars: environmental, economic and social (Giddings *et al.* 2002; Sandell *et al.* 2005; Boeve-de Pauw *et al.* 2015). Many consider an integrated approach to be important in order to incorporate all areas of sustainability. Lozano (2006) defines SD with a holistic consideration and strong emphasis on the role of society:

> *'a change process, in which the societies improve their quality of life, reaching dynamic equilibrium between the economic and social aspects, while protecting, caring for and improving the natural environment. This integration and equilibrium among these three aspects must be taught and transferred from this generation to the next and the next.'*

Contrastingly, Rauch (2002) describes each dimension in relation to sustainability. He termed environmental SD as the protection of natural resources, which ensures the natural cycle of local ecosystems and nature. He defined social SD as the coming together and cooperation of communities. Economic SD referred to quality of life relating to economic

self-determination and self-development for individuals and societies. Other authors have expressed SD as a dynamic concept, meaning it can be understood from several perspectives and there is no palpable definition (Haubrich *et al.* 2008; Makrakis 2010; Berglund *et al.* 2014). Hedenus *et al.* (2016) suggests the definition changes based on ethics and moral reasoning. People have varying opinions on what is valuable creating different perspectives built on personal ethics. Definitions can vary based on an academic, political, industrial and community background (Seyfang and Haxeltine 2012; Tonelli *et al.* 2013; Ramcilovic-Suominen and PüLzl 2018; Sinakou *et al.* 2018). It is the researcher who examines SD that should give a detailed description of the meaning, which they assign to it (Bonnett 1999; Berglund *et al.* 2014).

2.2 Climate Action Policy

In recent years there has been a significant shift in policy strategy relating to low carbon approaches and mitigation of climate change. Previously the attention was on a top down approach with centralised decision making. However, recent reports have highlighted the importance of local level engagement. In contrast to previous IPCC reports, the '*Synthesis Report of the Fifth Assessment Report*' (IPCC 2014) accentuates the importance of behavioural change, widespread adoption of energy efficient technologies and urban planning.

> *'Behaviour, lifestyle and culture have a considerable influence on energy use and associated emissions with high mitigation potential in some sectors' (IPCC 2014).*

> *'Emissions can be substantially lowered through changes in consumption patterns, adoption of energy saving measures, dietary change and reduction in food wastes' (IPCC 2014).*

Community based natural resource management was a recurring example of approaches for managing the risks of climate change through adaptation. The '*IPCC Special Report, on the Impacts of Global Warming of 1.5^{o}C*' (IPCC 2018), addresses community-based adaptation.

> *'Urban systems can harness the mega-trends of urbanisation, digitalisation, financialization and growing sub national commitment to smart cities, green cities, resilient cities, sustainable cities and adaptive*

> *cities, for the type of transformation change required by 1.5^{o}C consistent pathways' (IPCC 2018).*

The report highlights the 17 UN Sustainable Development Goals (SDGS), stating that '*mainstreaming community-based adaptation into planning and decision making enables attainment of SDGS 5, 10 and 16*'. The '*2030 United Nations Agenda for Sustainable Development*' brings together seventeen SDGs. Many of these relate to community participation with no. 11 being Sustainable Cities and Communities: Make cities and human settlements inclusive, safe, resilient and sustainable (UN 2015b).

In Ireland the national adaptation strategy, prepared under the Climate Action and Low Carbon Development Act 2015, takes the form of a National Adaptation Framework. The framework highlights the role of civil society in climate change adaptation.

> *'We need to consider innovative forms of communication so as to inform but also ensure society remains engaged on the long road ahead in making Ireland climate resilient by 2050' (DCCAE 2018).*

> *'Majority of adaptation actions will be taken by individuals, householders and businesses' (DCCAE 2018).*

The framework also mentions the Citizens' Assembly report on *'How the State Can Make Ireland a Leader in Tackling Climate Change'.* A primary outcome of the Citizens' Assembly report was the focus on local level engagement.

> *'We need citizens to be engaged and become active in the fight against climate change' (Citizens' Assembly 2018).*

The White Paper *'Ireland's Transition to a Low Carbon Energy Future 2015-2030'*, sets out a framework to guide policy and government actions in the energy sector up to 2030. While the paper addresses European and international climate change objectives, it also emphasises the importance of citizen engagement with an entire chapter titled '*From Passive Consumer to Active Consumer*'.

> *'There will be a new focus on citizens and communities as active participants, and agents of change in how we generate, transmit, store, conserve, and use our energy' (DCENR 2015).*

These statements reflect a significant change in climate policy, moving away from purely centralised decision-making toward localized actions which require high levels of information across a range of stakeholders (householders, businesses, local and regional governments). If decision-making needs to be improved at multiple scales, then better information is also required to ensure these stakeholders are empowered to create change.

2.3 Sustainable Communities

It is broadly accepted that community led initiatives form an intrinsic part of promoting social and technological change, through innovation and a unique driving force which is necessary in achieving a low carbon society (Urry 2009; Seyfang and Haxeltine 2012; Feola and Nunes 2014; Taylor Aiken 2015; Dinnie and Holstead 2018).

Sustainable community initiatives have been referred to in multiple ways throughout literature to include grassroots innovation and transition towns (Seyfang and Haxeltine 2012; Feola and Nunes 2014). It is evident that the role of community is central to grassroots innovations and transition towns (Aiken 2012), however the definition of community is ever changing. In the face of increasing urbanisation and globalisation, defining what is meant by community becomes more difficult. Many interpretations exist on the meaning of 'community' (Mannarini and Fedi 2009; Barrett 2015; Lazarus *et al.* 2016). McMillan and Chavis (1986) defined community in four aspects: membership (sense of belonging to a group), influence (feeling of ability to make a difference within the group), reinforcement (community can meet members' needs), and shared emotional connection (shared places and experiences). Other definitions have ranged from explaining the feeling of a sense of community to descriptions of a defined geographic space, and to interactions which occur amongst a particular group of people (Bell and Newby 1979; McMillan and Chavis 1986; Schuler 1996; Post 1997; Delanty 2003). Yet, all of these definitions relate to a common set of concepts (Lyon and Driskell 2011) with Jiang *et al.* (2013) describing community as being *'a group of interacting people who share the same environment, values or resources'*. ISO 37101:2016, which provides a management system for sustainable community development, offers a definition of a community as being a *'group of people with an arrangement of responsibilities, activities and relationships'* (International Organization for Standardization 2016).

The standard further states that *'In many, but not all, contexts, a community has a defined geographical boundary'*. Therefore, place does not necessarily constitute community

(Bradshaw 2013) and physical boundaries are not the only defining characteristic in a elaborate system open to different participants (Onyx and Leonard 2011). Similarly, Walker (2008), also contested the connection to physical space, by stating that communities may be based on shared interests such as culture and politics.

Identification of a tangible definition for community has proved subjective, as while many theories, studies and explanations on the meaning of community exist, no one definition will provide an explanation which will satisfy all authors (Cohen 1985). Cohen (1985) further recommended to look at how the term is used rather than a definite meaning. He found that community is a social construction, within which exists two related suggestions, that members of a particular group (a) have a common bond, which (b) distinguishes them from members of other groups. However, a clear understanding of the meaning of community within the context of this thesis is required. The definition needs to be practical and measurable, therefore, community is defined here as a group of citizens occupying a distinct physical space, capable of coming together for the purposes of developing and implementing a set of goals and actions leading to the achievement of greater sustainable development within that community. As such, the community requires a power of governance capable of making decisions and willing to take responsibility to ensure progress. It is acknowledged that such governance may function at a voluntary or professional level.

2.3.1 Key Sustainable Community Issues to Progress

It is widely recognised that grassroots innovations do not operate internally in practice as well as idealised in theory (Mulugetta *et al.* 2010; Walker 2011). The challenges lie within the struggle to maintain a sustainable space in the wider unsustainable regime of society (Seyfang and Haxeltine 2012). Literature points to an abundance of barriers ranging from societal and psychological, such as community engagement, behaviour change and networking (Rogers *et al.* 2008; Seyfang *et al.* 2010; Hielscher *et al.* 2011; Smith 2011; Seyfang and Haxeltine 2012; Drake and Lawson 2015; Heaslip *et al.* 2016), to lack of provision of relevant information involving technical, financial and legal matters (Walker 2008; Burch 2010; Feola and Nunes 2014; Byrne *et al.* 2017; Mosannenzadeh *et al.* 2017). For the purpose of this study the focus will be on the dissemination of relevant and useful information.

Heaslip *et al.* (2016) and Burch (2010) suggest that a comprehensive understanding of how barriers can be transformed into enablers supports the successful development of sustainable communities at the local level. In examining barriers to implementation of smart city projects in 43 European communities, Mosannenzadeh *et al.* (2017) identified 35 obstacles to success. They were categorised into policy, administrative, legal, financial, market, environmental, technical, social and information and awareness consensus. It was found that administrative, legal, financial and social barriers were correlated with the communities' specific traits. Correspondingly Feola and Nunes (2014) and Byrne *et al.* (2017) found securing funding was a major barrier to success. Communities rely on low levels of financial resources (Middlemiss and Parrish 2010). Lack of funding affects possibilities for collaborating effectively with other societal sectors, consolidating learning and diffusing oppositional ideas in the wider community (Seyfang and Smith 2007; Smith 2007; Seyfang 2009; Seyfang and Longhurst 2013). Additionally, innovations often depend on volunteers which can make it difficult to secure and sustain participation overtime (Kirwan *et al.* 2013; Ornetzeder and Rohracher 2013).

The formation of legal status has been proven to contribute to the success of transition initiatives (Mulgan 2006; Feola and Nunes 2014). Legal status creates the basis to form a structured group that is well governed, which plays a significant role in achieving community goals and protecting the interests of community members. The formation of a well-run and organised steering group is intrinsic to ensure progression of a sustainable community. Additionally, establishment of legal status encourages collaboration and interaction with local actors such as external organisations and local authorities (Feola and Nunes 2014). Therefore, the lack of relevant guidance on the formation of a legal structure, at the initial stages of forming a sustainable community, are an added barrier to success.

Evidently, progress toward a genuine sustainable society requires an informed public that supports the transition to a low carbon society (Middleton 2018). In order for the UN Sustainable Development Goals (SDGs) to be achieved, everyone must do their part, meaning every member of society must contribute to see real change. There needs to be an informed global public that agrees and supports the necessary changes.

While a significant body of literature exists on barriers to progression of sustainable communities, less studies have focused on the methods in which to overcome the identified obstacles. Extensive effort has been assigned to understand what the obstacles are with

review of previous work indicating a general theme of issues existing among funding, technical, legal, personal and conflicts of interest.

Research suggests there is major scope for further work to be conducted on identifying how these obstacles can be overcome. There is a substantial understanding of the problem but how can it be practically addressed. In examining barriers to environmental action in three Canadian cities, Burch (2010) found that '*addressing a lack of technical, financial or human resources is less a matter of creating more capacity than that of facilitating the effective use of existing resources*'. Agrawal and Gibson (1999) determined that an essential attribute to a community is the ability to make decisions and follow through with actions to achieve goals. Regional and local agencies in Ireland have expressed concern at the lack of clear guidance at national level (An Bord Pleanala 2017). Byrne *et al.* (2017) identified that a type of *'handbook or roadmap'* which provides practical information relating to legal and financial matters would be a positive asset to communities in Ireland. Therefore, there exists a gap for the development of a tool, aimed at the local level in Ireland, which contains the information needed to overcome the pre-determined barriers of financial, technical and legal matters. For this reason, research was conducted on decision support technology, which could be used by community members to aid decision making and progress to a sustainable community.

2.4 Decision Support Technology

The subsections explain the origin and definitions of decision support technology with an emphasis on Decision Support Systems (DSS), Decision Support Tools (DSTs), Decision Support Aids (DSAs) and Environmental Decision Support Systems (EDSS). The limitations of traditional DSS and alternative methods of development were also examined.

2.4.1 Definition of Decision Support Systems

Decision Support Systems (DSS) is a broad term which refers to interactive computer based tools developed to facilitate decision making and information dissemination (Daly 2016). They are designed to guide users through clear decision stages providing access to a variety of data and knowledge in order to complete decision process tasks (Parker 2004; Dicks *et al.* 2014). Shim *et al.* (2002) describes DSS as '*computer technology that can be used to support complex decision making and problem solving*'. According to Fox and Das (2000), a decision support system is a computer system which assists decision-makers in choosing between alternative options or actions by applying knowledge about the decision to

generate recommendations for the various options. It incorporates an explicit decision procedure based on a set of theoretical principles which justify the 'rationality' of this procedure. They endeavour to promote a natural intelligence approach to human problem solving through knowledge transfer (Webb 2011).

The DSS design literature generally identifies three major components of the system, dialogue management, model management and data management (Pearson and Shim 1995). These can be interpreted as database, model base and user interface. The classic DSS design is comprised of:

1. Database – sophisticated database management which has access to internal and external data, information and knowledge;
2. Modelbase – powerful modelling functions accessed by a model management system which comprise the what if component of the system;
3. User Interface – powerful yet simple user friendly interface designs which enable interactive queries, reporting and graphing functions (Shim *et al.* 2002).

Decision Support Tools (DST) and Decision Support Aids (DSA) can be categorised under the DSS umbrella, depending on their function and purpose. Classification should be made based on their complexity and inner workings (Power, 2016). Some are dynamic software tools providing recommendations based on the user's inputs which work by suggesting the most appropriate decision path. Here they would be referred to as a DST because artificial intelligence and modelling are used to generate results in relation to the user's inputs. However, there are other forms of DSS which may not be dynamic but instead act as information tools with the purpose of knowledge transfer (Rose *et al.* 2016). According to (Power 2016), '*a web page with decision aiding information or a simple web based checklist can be termed a decision aid'*. Therefore, for the purpose of this project non dynamic systems are referred to as DSA. The primary aim is knowledge transfer, whereby users are taking through decision stages and provided with relevant information at regular intervals in order to make an informed decision at the end of the process. The history and definitions which follow are centred on DSS as to cover the origin of the DST and DSA.

2.4.2 A Brief History of Decision Support Systems

'Decision-making' is generally defined as the act of choosing between alternative courses of action (Flynn and Williams 1998). Effective decision-making occurs when decision

makers choose the most appropriate course of action based on the information available (Cooke and Slack 1984; Drummond 1991; Williams and Kennedy 1999). Decision support technology originated in the 1960s as management information systems, which were predominantly used as a method of retrieving information from large databases catered to selected queries (Arnott and Pervan 2005). It was not until 1971, the term "Decision Support System" was created after appearing in a paper by Gorry and Scott Morton (1971). Traditionally, DSS were specifically aimed at top managers and executives, in organisations, to support decision making (Sprague 1982). Gorry and Scott Morton (1971) went on to develop a framework for improving management information systems with the help of literature by Anthony (1965) and Simon (1977), who dealt with categories of managerial activity and taxonomy of decision types. Simon (1977) categorised decision problems as programmed (routine, repetitive and well structured) and non-programmed (new, novel and ill structure). He compartmentalised the decision process into three components:

1. Intelligence: the need to make a decision, creating the problem;
2. Design: alternative methods of solving the problem;
3. Choice: Comparing the alternatives and choosing one for implementation.

The result of the integrated works was a table designed by Gorry and Scott Morton (1971), which defined decision problems as structured, unstructured and semi-structured instead of Simon's original programmed and non-programmed analogy. The concept was that the computer system handled the structured portion of the decision by automating the organised elements, and the human dealt with the complex unstructured areas using their own judgement of the problem, creating a symbiotic human-machine relationship. The overall purpose of the DSS was to improve the effectiveness of the decision maker (Arnott and Pervan 2005).

Sprague (1980) noted that the initial description of a DSS was too exclusive and altered it to include any system involved in the decision making process, rather than computer based interactive systems bringing a new and more evolved element to the definition.

The initial development of DSS was halted in its tracks as computers were not advanced enough, and such tools could not appear until direct access storage made interactive operating systems technically economically feasible (Courtney 2001). For this reason data

oriented DSS were the priority between 1970-1980 (Gorry and Scott Morton 1971; Simon 1977). Although Gorry and Scott Morton (1971) differentiated the needs of management information systems and DSS, emphasising that DSS required an interactive modelling systems, it was not until technology advanced that they could be introduced.

Aggarwal (2001) grouped the evolution of the DSS into four generations:

1. Data Centred
2. User-Interface Development
3. Model systems
4. Web – Based

Development of web technology drastically transformed the design, implementation and deployment of DSS (Bhargava *et al.* 2007). DSS remain extremely useful within organisations as Nof *et al.* (2006) states that '*the application of intelligent DSS can help enterprise cope with problems and uncertainty and complexity to increase efficiency and productivity in production networks*'. Daly (2016) suggests DSS are perceived to be capable of providing the necessary decision support that will aid a better decision making environment in organisations and result in greater success. However, due to several perspectives and varied dimensions of decision making, the DSS field evolved in different directions beyond management level and exclusively organisations (Suduc *et al.* 2010). The purpose of DSS diversified (Filip 2008; Nilsson *et al.* 2008). Nowadays DSS is associated with several domains including agriculture, biotechnology, finance, banking, manufacturing, health care, education and environmental (Huang *et al.* 2009; Lim and Jain 2010; Feghali *et al.* 2011; Al-Nory 2012; Raghupathy *et al.* 2013; Rose *et al.* 2016). They act as computerised information systems which support decision making activities.

2.4.3 Types of DSS

There are several types of DSS found in literature. Each have been explained in detail in Table 1.

Type	**Characteristics**
Communication Driven	• Emphasises shared decision making amongst a group of people. • Targeted at internal teams. • Helps users work together that are not in the same geographical area.

	• Examples include bulletin board, threaded email and instant messaging. • Most common technology used to deploy is client or web server.
Model Driven	• Based on quantitative models which help analyse decisions and choose between different options. • Uses input forms to obtain parameters entered by a decision maker to help analyse a situation. • Generates solutions based on parameters entered by the user. • Targeted at managers or business members. • Used for creating simulation models, performing production planning and scheduling, and creating statistical/ financial reports. • Deployed via software/hardware in computers, servers or the web.
Knowledge Driven	• Combine artificial intelligence with human cognitive capacities to make suggestions and support users in decision making. • Used by members of an organisation but also individuals who interact with that organisation such as the consumers. • Provides management advice. • Deployed via client/server systems, software on computers and the web.
Data Driven	• Provides access and manipulation of data tailored to specific task. • Relies on time series data. • Ability to support decision making in a range of situations. • Platform is generally client/server system or the web. • Useful when user needs to choose between many options.
Web-based	• The entire application is implemented using web technologies. • Application can be accessed from a web based component and displayed in a browser.

Table 1: Description of the different types of DSS (Nižetić *et al.* 2007; Dous *et al.* 2018).

The selection of type of DSS should be based on the specific purpose of the tool and end user requirements (Díez and McIntosh 2009).

2.4.4 Environmental Decision Support Technology

Environmental Decision Support Systems (EDSS) are a select branch of DSS. They have been defined as DSS developed for use in an environmental field that '*integrate models, or databases, or other decision aids*' (Rizzoli and Young 1997). Cortés *et al.* (2000) state EDSS play an important role in helping to reduce the risks resulting from the interaction of human societies and their natural environments.

EDSS originated from the effort to develop technologies which inform environmental policy and management organisations on solutions to complex problems (Guariso and Werthner 1989; Rizzoli and Young 1997). Therefore the vast majority of existing EDSS are aimed at environmental scientists, planners, policy makers, local authorities and

environmental managers (Culshaw *et al.* 2006; Matthies *et al.* 2007; Papathanasiou and Kenward 2014). Examples of these EDSS range from waste water treatment plant design (Hamouda 2011; Molinos-Senante *et al.* 2012; Garrido-Baserba *et al.* 2015; Zhao *et al.* 2019), river water management (Davis *et al.* 1991; Liao *et al.* 2011), urban planning (Coutinho-Rodrigues *et al.* 2011) ecological risk assessment (Isigonis *et al.* 2019) and contaminated land (Sorvari and Seppälä 2010; Döberl *et al.* 2013).

Rizzoli and Young (1997) and Matthies *et al.* (2007) describe 3 different types of users for EDSS: environmental scientists or system analysts, environmental managers and environmental stakeholders (landowners and conservation groups). Matthies *et al.* (2007) highlights the growing necessity for stakeholder engagement has been strongly supported by recent policy such as the Water Framework Directive in Europe. Additionally, climate action policy consistently refers to the important role of individuals and communities (DCENR 2015; IPCC 2018). The inclusion of stakeholder end users in EDSS development emerges as a crucial issue for future research (Matthies *et al.* 2007). There is considerable opportunity for the development of decision support technology aimed at a local level context however current DSS needs to be simplified to achieve this (Papathanasiou and Kenward 2014).

2.4.5 Limitations of DSS

A critical review of DSS and existing environmental decision support technology revealed that there were numerous issues associated with disseminating information to the wider public through a traditional DSS. DSS technology was generally aimed at management level in a specific organisation meaning the target audience is smaller and less diverse than the intended target audience for this project's development. Correspondingly, EDSS present similar problems. Previous studies (Papathanasiou and Kenward 2014) revealed individuals at the local level struggle to manage models of EDSS as they '*are not user-friendly enough to be used by non-scientists*'. Issues arose due to '*lack of IT education and training*' and '*complicated decision making processes*'. Technical design methods of EDSS and the level of complexity of tools vary depending on the intended users (Matthies *et al.* 2007). EDSS need to be shaped to meet different user requirements to ensure useful (relevant), usable (intuitive), and exchangeable (institutionally unobstructed) information is provided for decision support for different types of actors (Zulkafli *et al.* 2017). Therefore, when designing a DSS it is of the utmost importance to keep the end user

in mind at all aspects of development (Díez and McIntosh 2009). As the end user for this project differs drastically to traditional DSS there were a number of issues which have been outlined below.

1. The target audience for this project was the general public, individuals at a local level interested in sustainable living solutions. Consequently, the DSS needed to be user friendly and accessible. Papathanasiou and Kenward (2014) state '*If DSS are to help local management, systems are going to need to become comprehensive as well as user friendly*' and '*Much work is needed aiming at motivating the local community in order to endorse new and emerging technologies, especially web based tools for the protection of the local habitats*'. Therefore, there exists a difficulty in how to use the DSS in the first place from an end user perspective (Tatnall and Burgess 2007).

2. The main content to be disseminated was legal and financial information which is text heavy. The content was not a quantitative structured issue therefore the use of models and user input forms would be irrelevant. Rather the emphasis was on the database and user interface component of the DSS.

3. The time and feasibility of the project must be accounted for. The developer requires the platform to be manageable by non-technical individuals in order to keep the system updated by the environmental team.

4. The DSA also needed to be built within a limited timeframe and budget therefore the platform had to accommodate quick development and be inexpensive to work with.

DSS may be developed on various platforms as long as they support data storage, data analysis, solution method development and graphical user interface (Dous *et al.* 2018). As the model component is unnecessary, options were explored which accommodated a user interface and a database element.

Platforms	Delivery Mechanism
Spreadsheets	Excel
Web	Website or Content Management System
PDF Document	Adobe Acrobat Reader

Table 2: Alternative platforms of Decision Support Development.

It was determined that Excel and the web were suitable alternative platforms to build the DSA on as they both provided a straight forward user interface, wide accessibility to the end-user and feasible methods of development. A comparative analysis was conducted on both platforms to discover which was the most suitable for the requirements of the DSA.

2.4.6 Comparative Analysis of Spreadsheet and Web Based DSA

The platforms were compared on the specific criteria of the intended DSA. These included accessibility, user interface appearance, ability to accommodate text heavy content, navigation and how easily updated the platform was. The subsequent sections present a description and analysis of each platform based on the specified criteria.

2.4.6.1 Spreadsheet Based Decision Support Technology with Visual Basic Application

Spreadsheet based DSS are developed in a spreadsheet environment with the enhancement of a programming language and user interface developer (Seref and Ahuja 2008). Excel is the spreadsheet software and would comprise the database of the DSS, while Visual Basic Application (VBA) is a programming language used within Excel to accommodate the building of a user interface. The concept of spreadsheet based DSS is a recognised method for developing decision support applications (Bhargava *et al.* 1999; Seref *et al.* 2011). Spreadsheets make it possible for the user to access decision criteria and alter figures to see the effects it would have on the generated outcomes (Tatnall and Burgess 2007). Spreadsheets have been utilised for decision support in many ways. Buehlmann *et al.* (2000) developed a spreadsheet based decision support system for wood panel manufacturing using Excel and VBA. It is known as Lignum Optimizer and allows particle board plant managers to find the lowest cost solution for their production requirements. Ewing and Baker (2009) created an Excel based decision tool to support decisions on investment in green energy technologies. It allows users to select various combinations of green technologies and instantly see the financial and environmental impacts of their choice. The target audience were home and small business owners. It is site specific for people in the Pioneer Valley. Users can compare a buildings current energy consumption

with the expected performance given the implementation of one or several renewable energy or energy efficient technologies, such as solar panels and double pane windows. Design incorporates a working model with calculations which are available to be seen on other spreadsheets within the tool. The users are prompted to deal with the user interface which is made up of user friendly input forms. Users input their personal data and generate results.

2.4.6.2 Web Based Decision Support Technology

The web environment emerged as a very useful and important delivery platform for DSS (Shim *et al.* 2002). The web can be used to implement any category of DSS including communication driven, data driven, document driven, knowledge driven and model driven. Web based means the entire application is employed using web technologies (Power and Kaparthi 2001). Development of traditional web based DSS is a major task in relation to the user interface, models and data store construction (Power and Kaparthi 2001). In order to develop a web based DSS, an operating system, web server, database management system and a scripting language are required (Power 2018). The methods for developing a traditional web based DSS extend beyond this research therefore the prospect of a web based decision support aid was further analysed as an alternative. As described in section 2.4.1, Decision Support Tools (DST) and Decision Support Aids (DSA) can be categorised under the DSS umbrella, depending on their function and purpose (Power, 2016). DSTs are dynamic software tools which use artificial intelligence and modelling to generate results in relation to user's input. DSAs are non-dynamic forms which instead act as information tools with the purpose of knowledge transfer (Rose *et al.* 2016). As discussed, the model base is irrelevant in the context of this project therefore the focus is on web based decision support aids rather than tools.

With the prevalence and advances of computer technology and the internet, web and computer based decision aids have become increasingly more popular (Fleisher *et al.* 2014). Papathanasiou and Kenward (2014) state that web services have become more practical due to increased broadband and Wi-Fi connections in addition to the local population becoming more familiar with the web. Web-based decision aids possess the ability to employ multiple methods of presenting information tailored specifically to content, including audio, video and animation which add an extra element of interactivity to facilitate knowledge transfer (Allen and Berry 2011). Websites are considered an

important channel to communicate and convince stakeholders. Web technology has been used to develop decision support aids in various sectors. Patient decision aids are one of the most common categories addressed in literature (McCaffery *et al.* 2007; Raghupathy *et al.* 2013; Spiegle *et al.* 2013; Tan *et al.* 2016). In most cases these are built as a website or downloaded as a pdf document. Windsor Clinic Research Inc., in Canada, developed two patient decision aids focused on acne and psoriasis plaque (Cameron *et al.* 2018). Both were built in the same design format on a website platform to encourage accessibility and interactivity. The decision aid was presented in six stages, which represented a connecting journey. The six stages included: Introduction, My Options, My Skin, My Values, My Trade-offs and My Decision. The overall aim was to facilitate users make a decision regarding treatment options. Users could access all information freely or register in order to save their progress. The decision aids were logically presented, easy to navigate and interactive with a user-friendly interface. Other web based decision support aids have been developed in academia (Feghali *et al.* 2011), environmental agriculture and land management practices (Harrison *et al.* 2004; Carof and Godinot 2018; Zhang and Carter 2018) and local deer management processes (Webb 2011).

2.4.6.2.1 Accessibility

For the purpose of this project accessibility refers to the ability of the general public to access the DSA without difficulty. The use of a log in screen or paying to retrieve information would be considered a barrier to disseminating content of the DSA. Excel is a very popular spreadsheet package worldwide, however accessibility is limited to users with devices that contain the Microsoft Excel package. Additionally, Excel does not accommodate online access, further restricting availability to the general public. Instead an Excel file could be made downloadable from a website platform, but as noted the computer needs to be capable of accommodating Excel files. The web has been defined as the most accessible platform in current technology (Chen 2018). Any individual with an internet connection or access to a public library is capable of accessing the web. Therefore the web was recognized as a more accessible platform.

2.4.6.2.2 User Interface Appearance

User interface refers to the way in which the user will interact with the content and manner in which it is displayed. Excel provides a standard spreadsheet user interface which accommodates sorting of data and construction of models, charts and pivot tables (Seref and Ahuja 2008; Seref *et al.* 2011). Excel is a common platform, therefore an element of

familiarity is established with users who have worked with spreadsheets previously, aiding their user interaction experience (Ewing and Baker 2009). However, it is impossible to guarantee all users will have experience with spreadsheet software and standard spreadsheet user interface can be overcrowded creating visual complexity and inhibiting user interaction and comprehension. Incorporation of Visual Basic Application (VBA) allows for the building of a user interface and manipulation of Excel objects, therefore spreadsheets offer additional user interface options from basic formatting to more advanced input forms and control tools (Seref and Ahuja 2008). However the increased functionality offered by VBA is more suitable for model driven decision support technology to accommodate what if calculations and generate results based on user's feedback (Seref and Ahuja 2008). Figure 1 displays an example of the user interface capabilities of VBA highlighting its limitations.

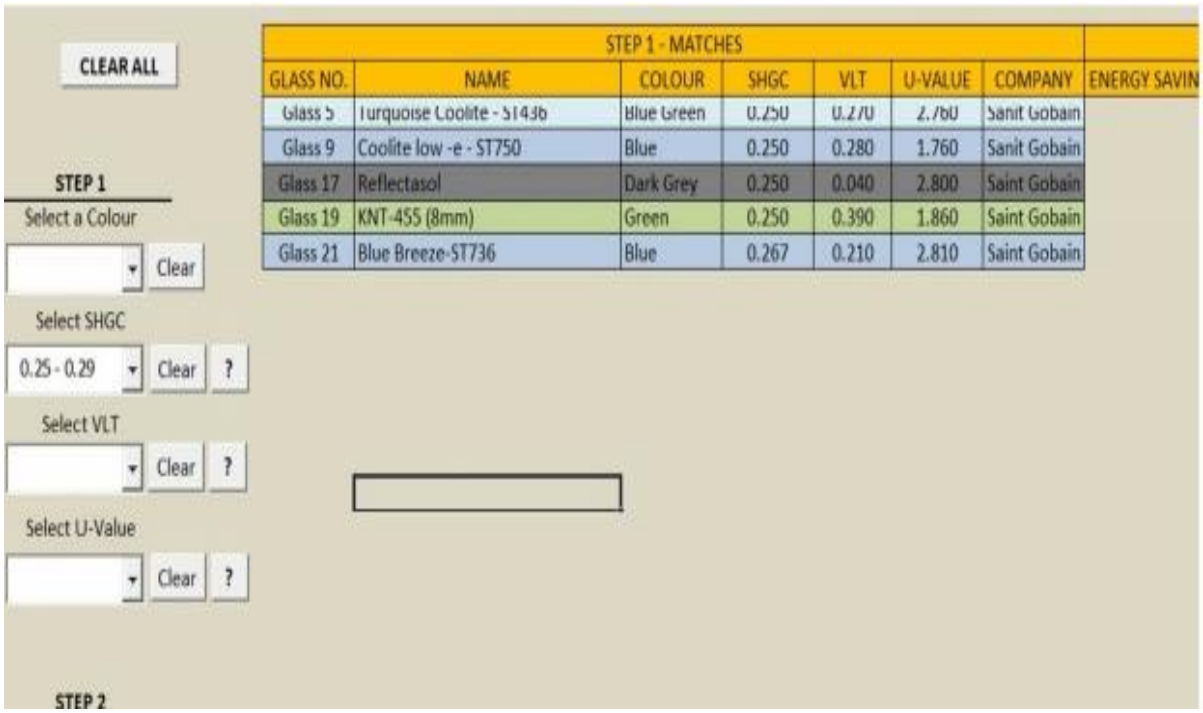


Figure 1: Example of VBA user interface for an Excel based decision support system (Mohamed *et al.* 2012).

Web based applications provide greater variety for user interface manipulation. It is widely recognised that the success of a website is dependent on its usability (Fang and Holsapple 2007; Lee and Kozar 2012). With web based applications the developer can build the website from scratch or use prebuilt layouts modified for enhanced user experience. As web based applications are more customisable it is easier to incorporate user-centred design elements. Additionally, websites deliver a platform to establish a unique and personal

appearance, making the DSA more distinguished and memorable to users. Therefore, web based platforms possess an advantage over spreadsheets in relation to user-interface appearance due to their customisable nature and ability to incorporate user-centred design elements specific to the intended target audience.

2.4.6.2.3 Ability to Accommodate Text Heavy Content

The ability to accommodate text heavy content was a crucial characteristic of the intended development platform. The DSA was content driven as it focused on providing specific information to the end users (Dawson 2010). Spreadsheet based decision support technology supports the development of model and data driven DSS where the primary data is in numerical format (Power 2017). VBA can be used to incorporate more text however this would be a time consuming process as coding is necessary. The VBA extension is more appropriate for creating user forms where users can input data and generate results (Seref and Ahuja 2008). Contrastingly websites support a vast amount of text. If a website is being developed from scratch content needs to be coded, however there are alternative methods such as Content Management Systems (CMS), which facilitate the building of websites in plain text format, therefore eliminating the necessity to code and programme (Cabot 2018). Furthermore it is easier to manage and organise information rich content on web based platforms as the user interface is more adaptable than spread sheet based platforms. Therefore, web based platforms provide greater capabilities for handling text heavy content than spreadsheets.

2.4.6.2.4 Navigation

Navigation is defined as the way in which users move through the spreadsheet or website user interface. Positive navigation encompasses salient and consistent navigation/menu bars, visible links and search features (Garett *et al.* 2016). As website applications are more customisable and incorporate greater functionality, it is easier to integrate positive navigation design. A major downfall with Excel navigation is the initial security warning message which appears when users download an Excel file. See Figure 2 for an example.

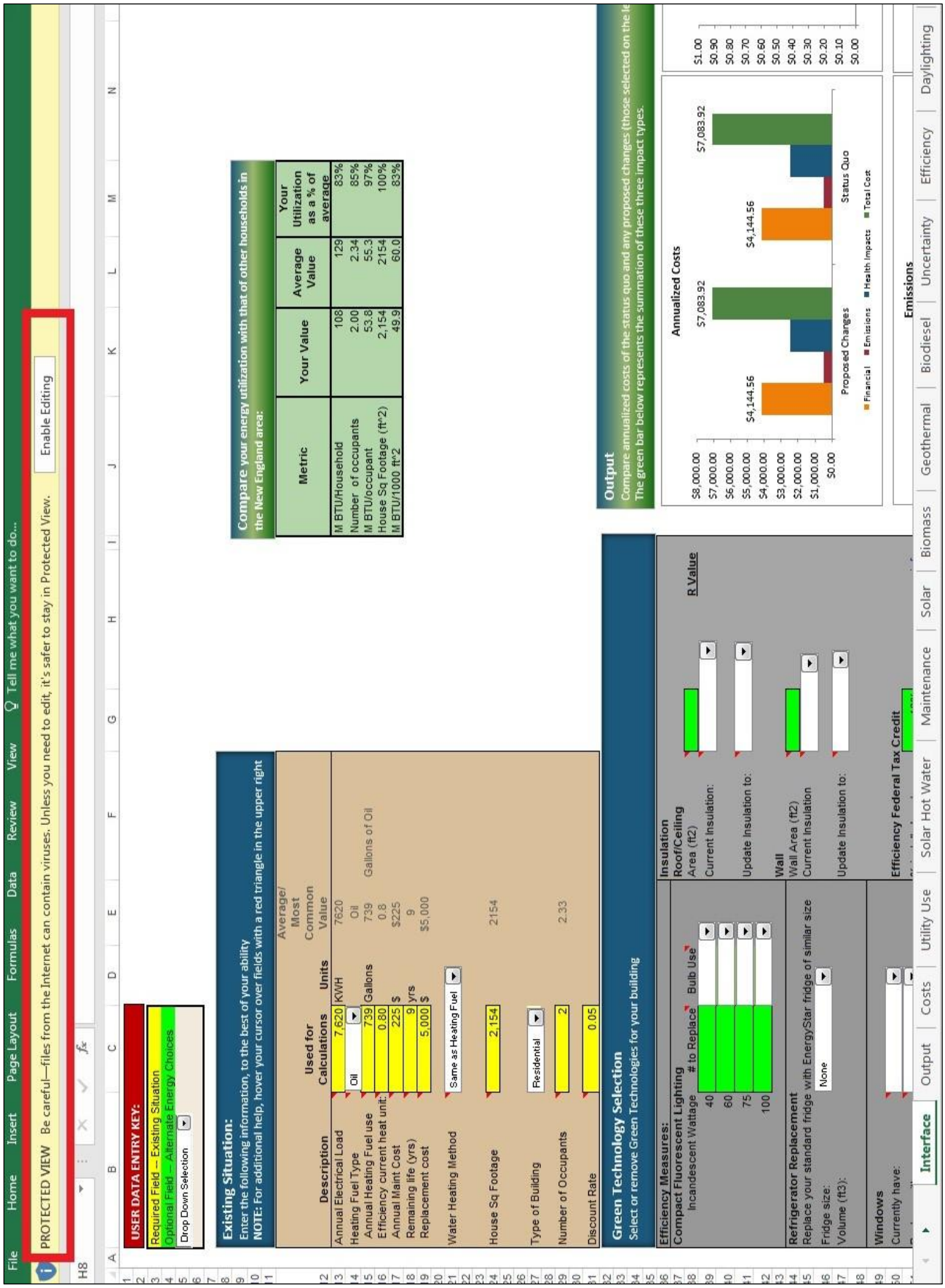


Figure 2: Pioneer Valley Sustainability Decision Tool to demonstrate warning message on Excel based DST (Pioneer Valley Sustainability Network 2009)

The user must enable editing and macros to use the DSA to its full potential, however this action is accompanied by a warning message stating ‘Be careful – Files from the Internet can contain viruses. Unless you need to edit, it is safer to stay in Protected View.’. Figure 2 presents an example using a sustainability focused Excel based DST. This is a major disincentive to use Excel based DSAs. Therefore web based platforms triumph again with greater ease of use as a result of straightforward navigation.

2.4.6.2.5 Easily Updated

The platform of development needed to be easy to use from the developer’s perspective, in order for the research team to access the database and edit content appropriately. The information sourced consisted of external links to application forms which were subject to change based on dates of submission. Therefore, content required regularly updating to ensure accuracy of information and operational links. Building a DSA using Excel and VBA is more time intensive as there is a steeper learning curve in relation to code and therefore greater opportunity for error. Depending on the method used to build a web based DSA, the database can be easily accessed and updated in plain text therefore reducing the possibility of mistakes. Consequently, web based platforms were recognized as more easily updated.

2.4.6.2.6 Conclusion

Evidently, web based applications were identified as the most appropriate platform of development for the purpose of this DSA project. Table 3 summarises the findings of the comparative analysis.

Platform Type	**Spreadsheet**	**Web-Based**
Description	Excel with Visual Basic Application (VBA).	Decision support aid built in website environment.
Accessibility	Limited due to user’s specific device accommodating Excel package.	Most accessible platform in current technology.
User-Interface Appearance	Plain but can easily become overcomplicated and visually complex	Customisable therefore can incorporate user-design criteria and make more unique and memorable.
Ability to Accommodate Text Heavy Content	Works best when organising with numerical data.	Easier to manage and organise text rich content as user-interface is more adaptable.

Navigation	Warning message accompanying downloadable Excel files acts as disincentive and promotes poor navigation.	Provide greater functionality and interactivity to organise navigation and promote ease of use.
Easily Updated	Difficult to update due to learning curve associated with VBA.	Dependent on how the website is developed. If Content Management used, updating is straight forward, however if coded from scratch it will be more complicated.

Table 3: Summary of comparative analysis between spreadsheet and web based platforms for DSA development.

Web based accommodates the specific criteria of the intended content driven DSA by integrating content heavy material into an easy to navigate and user friendly interface with extended features for increased functionality. Excel based DSA would be more relevant for conducting measurements and quantifying data which was not the aim of this study. Furthermore, web based forms of EDSS have been recognised as the optimal method for a higher degree of information integration and interactivity (Zulkafli *et al.* 2017)**.** Chen (2018) states '*with the rapid advancements in internet technologies, websites have become an unparalleled platform for people to explore information and acquire knowledge*'. Therefore the DSA was web based, in that the decision stages were represented by the primary, secondary and tertiary navigation menus of the website.

2.4.7 Comparative Analysis of Website Development Methods

Conventionally websites are built using a mark-up language such as HTML or PHP and styled by incorporating cascading style sheets also known as CSS. Alternatively, websites can be developed using a Content Management System. A Content Management System (CMS) is a system which accommodates the creation and publication of digital content for development of websites including blogs, online stores and forums (Cabot 2018). It uses a 'what you see is what you get' text editor therefore eliminating the necessity to code. In order to determine which method was most suitable for development of the web based DSA a comparative analysis was undertaken based on learning curve (technical knowledge and design skills), appearance, maintenance, time and cost. Table 4 summarises the main differences.

Method	Content Management System	Coding, CSS and Database Connectivity
Description	Website builder for e.g. WordPress and Drupal.	Building website from scratch using HTML, PHP and CSS.
Technical Knowledge	User-friendly and do not need prior programming knowledge.	Need programming knowledge.
Design Skills	Pre-designed templates available with enhanced user centred design.	Manually designing websites using code.
Appearance	Professional and unique appearance as thousands of templates available.	More customisable appearance but need design skills with code and programming.
Maintenance	Easily updated without technical support.	Will not be easily updated because using coding language.
Time	Not as time consuming because data is in plain English.	More time consuming as data needs to be coded.
Cost	Domain name, web hosting, personal training and plugins.	Hire web developer with technical and design skills therefore higher cost.

Table 4: Comparison of building a website using a CMS or from scratch with HTML/PHP and CSS (Simpson 2005; Hubble *et al.* 2011; Patel *et al.* 2011; Amberd 2017; Cabot 2018).

Comparing the two methods revealed that the employment of a CMS was more suitable as it met the criteria of the DSA. While both provide a professional looking website, the CMS allows for non-technical individuals to construct the website and update content without using coding and programming languages. Constructing the website from scratch would be resource intensive and time consuming, as there is a steeper learning curve in relation to technical knowledge of coding, programming and design. Furthermore, it would be costlier if a web developer was hired. Additionally, discussions with the Computer Science and Information Systems department in UL and review of literature further highlighted the advantages of CMS over a static website.

> *'A CMS is now the preferred choice for those who want easy content changes, simplified control of large amounts of content, a choice of plug-ins to accomplish a wide variety of tasks; and above all, the ability to do a lot more, a lot easier, and a lot faster than with any other system' (Patel et al. 2011).*

Therefore, it was determined that the DSA would be built using a CMS.

2.4.8 Comparative Analysis of Content Management Systems

There are a wide variety of CMSs to choose from, however some are more popular than others due to their functionality and support (Patel *et al.* 2011). Functionality refers to the way in which a user interacts with the website. The focus is on quality of information provision, including website content and features (Louw 2017). It is considered one of the most important website design characteristics (Gretzel *et al.* 2000; Dawson 2010). Support refers to online availability of help and tutorials concerning how to use the CMS. Three of the most used CMSs include WordPress, Joomla and Drupal (Patel *et al.* 2011). WordPress (WP) is the most popular, powering up to 33% of all websites (W3Techs 2019) and 60% of all websites which use a CMS (Cabot 2018). Joomla represents the second most popular CMS with a considerable gap powering around 3% of all public websites, and Drupal is a close third, powering slightly more than 2% of websites (Clobridge 2016). Each CMS was reviewed based on learning curve, support, functionality and cost.

2.4.8.1 WordPress

WP was developed in 2003, by Matt Mullenweg and Mike Little (Cabot 2018). It originated as a blogging tool, but expanded over several years to accommodate the creation of multi-purpose websites (Patel *et al.* 2011). It is widely reported as an easy to use platform with straight forward installation (Leary 2009; Jones and Farrington 2011; Clobridge 2016; Cabot 2018). The developer does not need prior knowledge of coding languages as the text editor is in plain English, similar to Word documents. There are a wide variety of pre-built themes which the developer can choose from, therefore knowledge of design with code and programming is also unnecessary. As WP is the most popular open source CMS, there is a vast online community of support including websites dedicated to WordPress beginners, online tutorials, handbooks and active forums (Mening 2018). Additionally, there are numerous online courses from websites such as Udemy, for beginners to advanced users. The functionality of WP websites can be increased through the addition of plugins. Plugins are added features such as calendars, contact forms, decision trees, layout builders, security, search engine optimisation, timelines, image carousels and galleries. WP is free to install however certain plugins and themes cost money, therefore the overall cost is dependent on the purpose of the website being developed.

2.4.8.2 Joomla

Joomla originated as 'Mambo', an internal CMS product built by a group of engineers at Miro Corporation of Australia in 2001. It was not until 2005 it was revamped as Joomla and has since undergone numerous updates but remained the same name and platform (Rahmel 2009). Parallel to WP, it is an open source free CMS with prebuilt templates, meaning there is no need to understand code or programming languages (Patel *et al.* 2011). However, the learning curve has been described as more challenging than WP (Mening 2018; CMS Platforms 2019). While WP has plugins, Joomla has extensions. Although these extensions promote greater functionality, many require manual installation, meaning a more advanced knowledge set is necessary to optimise the CMS (CMS Platforms 2019). Similar to WP, there is a substantial amount of help and support through online public supported handbooks and a community help portal where users can ask specific questions. The employment of Joomla is generally most suited to e-commerce and social networking websites, because it offers built-in functionalities to enable user-generated content such as membership sites and forums (Mening 2018). Joomla is similar to WordPress as being free to install with additional expenses related to extended features. However, as Joomla has a steeper learning curve there may be extra costs associated with hiring a developer (Mening 2018).

2.4.8.3 Drupal

Drupal's first version emerged in 2001 making it the earliest CMS in this comparative (Mening 2018). It was developed by a Dutch University Student, Dries Buytaert, as a college project which grew into an open source CMS (Tomlinson 2010). Drupal is recognised as a technically advanced CMS, which is not suitable for beginners due to its challenging interface and steep learning curve (Hubble *et al.* 2011; Mening 2018). In order to develop a professional website on Drupal, a knowledge of HTML and PHP would be necessary. There is online support available due to its popularity (Patel *et al.* 2011), however considerable time and training would be needed to utilise Drupal to its full potential. It is the most customisable CMS compared to WP and Joomla, therefore making it more functional (Ray and Ramesh 2016). For this reason Drupal would be most suitable for large, custom, enterprise level websites (Mening 2018). The costs associated with Drupal installation and it's extended features are similar to WP and Joomla, however as Drupal is the most technically advanced with the greatest learning curve, a developer would need to be hired which would increase the cost of the project significantly.

2.4.8.4 Conclusion

The comparative analysis of the three CMS revealed WP to be the most user friendly and appropriate for beginners. Therefore, presenting an achievable learning curve in the time frame of this project. As it is the most popular CMS, it also provides the widest online support amongst the three. Online forums are widely available to ask specific questions regarding the platform. Furthermore, as WP is the most straight forward CMS to work with, the ability to extend functionality with incorporation of plugins would be more attainable. Finally, the cost would solely involve installation, web hosting and domain name purchase, as hiring a web developer would be unnecessary. Therefore the web based DSA was developed on WordPress.

2.5 Web Based Decision Support Technology

In order to build an efficient, professional and practical web based DSA, research was undertaken in relation to user-centred design strategy and review of existing environmental and sustainability web aids. This step was essential to determine methods of presenting content rich information in a user-friendly, engaging manner and to identify the current knowledge gap in provision of online information.

2.5.1 User-Centred Design

Usability is widely recognised as a heavily dependent factor of successful websites (Galletta *et al.* 2006; Fang and Holsapple 2007; Lee and Kozar 2012). The ISO 9241-11 standards on human computer interaction refer to usability as '*extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use*' (ISO 2018). User centred design refers to the process of creating products with the end user in mind (O'Connor 2009). It is focused on the people, specifically their goals and needs. In order to engage users, content needs to be easy to find, easy to understand and accurate (Redish 2012). A review of literature revealed several predominant categories of user centred design, accompanied by corresponding guidelines for creating user focused content (Hassan and Li 2005; Schmidt 2011; Lee and Kozar 2012; Redish 2012; Garett *et al.* 2016). These are outlined in Table 5.

Category	Guidelines
Screen Appearance	• Non excessive use of colour for text • Sharp colour contrast between text and its background • Use of colour to differentiate between functional area with content display • Different text sizes to differentiate between titles, headings and text • Avoidance of background images in the content display area • Clear titles for each page • Clear headings, sub headings • Use of typography (e.g. bold font) • Skimming layout • Use passive and active space effectively • Avoid false bottoms (large white space or horizontal lines making users think they do not need to scroll beyond the fold)
Accessibility	• Compatible display for different screen times • Use of local search facility
Navigation	• List of key content on the main page • Accurate links • Use of sitemap • Menus that fit on screen • Menus placed at the top of a page horizontally or vertically at the left of a page elicit enhanced performance in users • Consistency of navigation • Use of text within links
Media Use	• Control feature for continuous media such as carousel • Avoidance of looping animation • Labelling all static media • Only use when relevant • Place active space around images
Interactivity	• Availability of features for users' feedback about site such as email or online form • Availability of features for sharing views such as comments • Availability of entertainment features such as online games and puzzles
Consistency	• Consistent page layout for screen size, banners, menu bar • Consistent use of text font, size and colour • Consistent use of navigational aids so that links are all the same size and colour
Content	• Put the important information first 'inverted pyramid' • Relevant to the purpose of the website • Use of lists • Short paragraphs • Short sentences • Up to date information • Do not centre text, always left justification • Do not underline

	• Background information of institution/owner of the site for authority and reliability • Option for printer friendly pages • Choices of language • Information warnings on file size for download • Clear distinction between internal and external links • Links to other relevant web sites
Readability	• Suitable language for all users • Write in a conversation like manner using 'you' and 'we' • Grammatically correct • Appropriate amount of content on each page

Table 5: Summary of guidelines associated with successful user-centred design (Hassan and Li 2005; Schmidt 2011; Lee and Kozar 2012; Redish 2012; Murano and Lomas 2015; Garett *et al.* 2016; Zulkafli *et al.* 2017; Chen 2018).

Furthermore, it is important to note the minimum click rule in terms of navigation. Users need to be able to find desired information quickly otherwise they will look elsewhere. Studies have highlighted a positive correlation between the number of mouse clicks and the perception of difficulty by users (Thurow and Musica 2009; Macdorman *et al.* 2011; Jiménez Iglesias *et al.* 2018). In order to design and present content in an engaging manner, that promotes human computer interaction and reduces information overload, these guidelines were integrated into the design and construction phase of the web based DSA.

2.5.2 Review of Existing Environmental and Sustainability Web Aids

In the last decade there has been a large increase in the number of web aids available to support communities and individuals transition to a more sustainable lifestyle. In order to determine what was necessary to build the decision support aid, a number of these tools were reviewed under the following assessment framework:

1. Accessibility
2. Usability
3. Navigation
4. Platform of Development
5. Content

The assessment framework was derived from the identified user-centred design guidelines in Section 2.5.1. The aim was to determine the range of tools already available and identify their functionality, quality and usefulness. A description of each is outlined in the subsequent sections with strengths and weaknesses highlighted.

2.5.2.1 Community and Renewable Energy Scheme (CARES) Toolkit

CARES Toolkit (Local Enegy Scotland 2019) was developed on a web based platform, by Local Energy Scotland, to aid community groups and rural businesses undertake local level renewable energy initiatives. The toolkit provides guidance to community groups in developing their renewable energy project, from initial concept to construction and operation. The toolkit comprises a vast amount of technical content, however developers have promoted usability by initially presenting a list of bullet points indicating how to manoeuvre the toolkit. Users are advised to download the accompanying handbook if they are not familiar with the toolkit. Content is categorised into five sections; technology options, business planning, setting up an organisation, project development and downloadable tools. Each category has several sub categories that comprise the modules of the toolkit, which are downloadable pdfs. The simplistic layout promotes ease of navigation and the modules maintain a consistent structure allowing users to develop familiar usage patterns. The technology options are segregated into several projects including local energy supply, wind, hydropower, solar pv, solar thermal, biomass, microgrid-private wire, electrical energy storage, heat pumps and innovative energy systems. Content is diverse in addressing community groups starting out and existing groups. Information consists of how to establish a community group, legal entities, sources of finance, securing a site, grid connection, construction process of renewable projects and overall maintenance. The platform is extremely accessible as all information is free to retrieve and download without registration or payment.

Strengths: The CARES Toolkit is of great benefit to new and established community groups containing practical detailed information to get started, set up local energy projects and manage them post development. They have organised a content heavy tool into a structured easy to navigate website using a simplistic and consistent layout, where the information is completely free to access.

Weaknesses: Information is aimed at Scottish communities and would therefore be less applicable to Irish communities. The tool is primarily pdf documents therefore greater interaction could be incorporated to ensure user engagement. Additionally, content is solely focused on energy projects.

2.5.2.2 Community Energy Plus

Community Energy Plus (Community Energy Plus 2019) is a social enterprise in Cornwall which provides information on energy efficiency. They developed the Community Energy Toolkit on a web based platform and it is accessible from their main website. Navigation consists of a primary menu, representing the main sections of the toolkit, and a secondary menu containing more detailed content relevant to the main sections. Content is based on three scenarios: reducing energy in the community; transforming energy use in community buildings and community renewable projects. The tool aims to provide individuals and community members with practical information on how to initially get a group together, organising a legal structure and maintenance of the established group. The second section focuses on the energy solutions and actions taken. While the third section presents funding sources relevant to those actions. Resources include links to external websites and downloadable pdfs. Overall, navigation is effortless due to the straight forward layout of the Homepage, incorporation of short paragraphs and use of headlines which aid scannability and readability. The entirety of information is freely available meaning accessibility is excellent. The tool itself is English based and aimed specifically at Devon and Cornwall community groups.

Strengths: The Community Energy Toolkit promotes easy navigation and usability due to a simple layout, short concise paragraphs and user friendly language. The information is free to access. Their goals are achievable and cater to all levels of understanding from individuals wanting to get involved, to experienced community groups.

Weaknesses: The Community Energy Toolkit is solely energy focused and does not address other aspects of sustainable development. Furthermore, it is site specific for users living in Devon and Cornwall in England.

2.5.2.3 Community Planning Toolkit

The Community Planning Toolkit was developed by Community Places (Community Places 2012), a not for profit social enterprise based in Belfast which provides free, independent and professional advice on planning issues to individuals and community groups. The community and voluntary sector are the prime target audience however it is also intended for use by local authorities, elected representatives, statutory service providers and private sector interests. The toolkit is built on a web based platform and content is segregated into five dominant themes including, Community Planning,

Community Engagement, Working Together, Outcomes Approach and Achieving Alignment. Each theme has an associated pdf document containing the principal information, a list of short podcasts and a resources section comprising of external links to other online tools and useful articles. Information is freely available online promoting easy accessibility.

Strengths: Community Planning Toolkit is extremely accessible with a straight forward user interface, brief explanations of each theme, short paragraphs, use of bullet points to split up text, varied media and categorisation of content contributing to excellent navigation and usability. The layout of each theme remains consistent to aid familiarity with users. The inclusion of a 'How To' section further contributes to ease of use by detailing how to manoeuvre the toolkit. The content has been informed through extensive research on real community groups making it very relevant and useful.

Weaknesses: The toolkit would not be suitable for a community group starting out. Although the content is extremely useful, the reading level is very high and the work load is ambitious for beginners. There is also little mention of legal structures. Additionally, the text could be more interactive as the main content is found on pdf documents which are vastly text heavy.

2.5.2.4 Community Toolbox

Community Toolbox was developed by Kansas Centre for Community Health and Development as a public service of the University of Kansas (Community Tool Box 2018). It is a web based platform of content rich information focused on learning skills, teaching others and taking action in organising community development. The target audience is any community or individual interested in sustainable action and change. Each webpage presents a similar web layout therefore promoting usage patterns and familiarity. Navigation is representative of a common website format, featuring a horizontal navigation bar located at the top of the webpage with additional interactive icons to access the main information. The primary content consists of 46 chapters and 16 related toolkits, online modules, community stories, social media to get in touch with other communities, training and a database of external resources.

Strengths: The content is extremely useful and comprehensive in terms of addressing several aspects of forming a sustainable community. Training and online modules are an

asset for practical learning. Multiple access routes to retrieve information aids ease of navigation.

Weaknesses: As the web aid has tackled sustainable community formation in a comprehensive manner, the webpages are content heavy resulting in information overload. Webpages maintain a consistent layout which is positive in allowing users to create usage patterns, however more interactive material is needed to engage users and keep them interested. Furthermore, content is of a high reading level acting as a disincentive for new community groups to utilise the web aid to its full potential.

2.5.2.5 CURB Tool – Climate Action for Urban Sustainability

CURB is a data driven Excel based scenario planning tool aimed at cities to reduce environmental impacts (The World Bank 2016). It was developed by The World Bank in partnership with Bloomberg Philanthropies, AECOM Consulting and C40 Cities Climate Leadership Group. Integrated planning information is provided across six sectors: Private Building Energy, Municipal Building and Public Lighting, Electricity Generation, Solid Waste, Water and Wastewater and Transportation. There are six modules where users input information and generate results. These include the setup, inventory, context, actions, results and database. Local data is used to help cities evaluate low carbon actions that are city specific. The tool is aimed at city officials rather than the local community. It provides support to city officials in prioritising and planning cost effective ways to reduce carbon emissions through tailored analyses. It is freely available to download as an Excel file.

Strengths: CURB is an extremely useful measuring tool for making decision based on generated genuine values and criteria. Ease of use is promoted by the accompanying training videos, user guide and technical support.

Weaknesses: Accessibility is reduced by the necessity to register in order to download the link. Also users must ensure their device supports Excel. Furthermore, it is aimed at city officials rather than local level sustainable community groups.

2.5.2.6 The Wheel

The Wheel are the national association of community and voluntary organisations, charities and social enterprises in Ireland (The Wheel 2019). Their website provides an abundance of information with the focus on charities and non-profit organisations. Advice and guidance is disseminated through training events, web pages, handbooks in the form of pdfs and links to external resources. Information relates to forming an organisation which

includes legal forms, funding, governance, management and promotion. The website is charity focused however there are several handbooks and two external websites aimed at sustainable community groups (Spark Change 2018; Sustainable Communities Toolkit 2018). These include:

1. Sustainable Communities: A Governance Resource Book for Small Community and Voluntary Organisations (pdf).
2. Sustainable Communities Funding Handbook (pdf).
3. Fundingpoint (part of the main Wheel website).
4. Sustainable Communities Toolkit (website).
5. Spark Change (website).
6. The Governance code (pdf).

Strengths: Irish specific information with a detailed approach to legal forms and application process for grants. There are multiple routes of accessing the same information. The content is extremely relevant and useful for sustainable community development in Ireland. The addition of organised training events for practical learning is an asset. The Sustainable Communities Toolkit website presents useful action ideas to get community groups brainstorming with straightforward navigation.

Weaknesses: The website is charity focused and therefore hard to distinguish and locate sustainable community specific information. The content is of a high reading level and a lot of the sustainable community relevant information are on pdf documents therefore interactivity is limited. The website is membership focused with Fundingpoint only available to members and at a cost. The Sustainable Communities Toolkit website presents themes which are not representative of the content with a high reading level. Furthermore there is no introduction on how to get started as a community group, therefore limiting the target audience to existing sustainable communities. The main Wheel website navigation is complicated as it is difficult to locate information, and not all of their accompanying websites accommodate a search facility.

2.5.2.7 VOiCE – Visioning Outcomes in Community Engagement

VOiCE was developed by the Scottish Community Development Centre to implement the National Standards for Community Engagement (VOiCE 2019). The primary purpose of VOiCE is to enable users to analyse, plan, monitor, evaluate and record community

engagement. Therefore, it is focused on the organisation of community engagement initiatives. The target audience are Scottish based individuals, organisations and partnerships. The content is organised in four sections: Analyse, Plan, Do and Review. In order to access the platform users must create an account.

Strengths: VOiCE would be very useful for an established community group who want to organise community engagement initiatives, as it provides a structured procedure to aid the overall process.

Weaknesses: VOiCE is not aimed at local level beginners as it is exclusively community engagement relevant, therefore a group starting out would need more basic information prior to this stage of community development. Accessibility is restricted due to necessity to register and log in to access and it is only suitable for Scottish based users.

2.5.2.8 Conclusion

While the aids described above have some similarities to the focus of this project, none satisfy the demand for the decision support necessary at the Irish local level. Table 6 summarises the findings of the review focusing on the identified knowledge gap associated with each web based aid and how this research will bridge the gap.

Web-based Aid	Findings	Bridging the knowledge gap
CARES Toolkit	Solely energy focused with large pdf documents and site specific to Scotland.	Broaden scope beyond energy, make Irish specific and use web tools to increase interactivity.
Community Energy Plus	Solely energy focused and site specific to Devon, England.	Broaden scope beyond energy and make Irish specific.
Community Planning Toolkit	Not suitable for beginners, does not address legal structures, pdf documents are text heavy and of a high reading level.	Address communities starting out to ease users into technical information. Include legal content and ensure basic reading level.
Community Toolbox	Content heavy webpages with plain outline that promotes immediate information overload. Also American specific.	Ensure content is written in a personal positive manner and broken up using short paragraphs and bullet points to aid scannability and usability. Include more interactive material such as expandable lists.

CURB	Measuring tool aimed at city officials therefore less applicable at the local level.	Focus on dissemination of information which is useful at the local level rather than numerical measurements.
The Wheel	Large amount of useful information available but issues relating to clarity as it is difficult to locate sustainable community specific information. The sustainable community relevant content is available in pdf form which limits interactivity.	Utilise the web platform to make information more interactive. Ensure a clear navigation process to accessing information. Emphasis the focus of sustainable communities ensuring users understand who the website is aimed at.
VOiCE	Not suitable for beginning groups as focused on planning and measuring community engagement. Scottish based web aid.	Build an accessible web platform which does not need registration to download and incorporates all levels of understanding for Irish specific communities.

Table 6: Summary of existing sustainability and environmental web aids with associated knowledge gap.

There are several tools available in England and Scotland that can inspire the development of more Irish based aids. The majority of these tools would be useful for established community groups with few aimed at beginner level. Additionally, many of the tools have a measurement and energy focus therefore a gap exists for more information based aids.

3 Methodology

The process of selecting the most appropriate research method, is predominantly based on the intention of the research objectives and the type of data needed (Yin 2009). Due to the broad scope of this study, a variety of techniques were adopted. Table 7 represents a research roadmap of objectives, tasks and methods used to carry out the entire project. Table 7 indicates the research tasks and methods chosen, based on the objectives. It is important to note that work was carried out by the author except when specified otherwise.

Project Aim: To develop a decision support aid which facilitates progression of sustainable communities in Ireland through knowledge transfer		
Objective	**Task**	**Method**
1. Investigate the barriers to progression of sustainable communities.	• Review historical context of sustainable development and how it is understood by different sectors. • Determine the issues associated with sustainable communities and the barriers to success.	• Literature Review
2. Investigate current environmental and sustainability web aids.	• Review current sustainability aids to determine the knowledge gap in the provision of online information.	• Literature Review • Assessment
3. Identify goals of the Decision Support Aid (DSA).	• Outline the purpose and goals of the DSA based on the knowledge gap.	• Based on combination of previous literature review and assessment
4. Identify target audience.	• Develop user profiles to ensure all levels of understanding are addressed.	• User-centred Design
5. Gather useful content.	• Content influenced by literature review, evaluation of current sustainability tools and identification of target audience.	• Based on combination of previous literature review and assessment
6. Determine most appropriate platform for development of DSA.	• Review Decision Support System (DSS) Technology to identify suitable platform. • Compare spreadsheet and web based DSA.	• Critical Review • Literature Review • Comparative Analysis

	• Consult with computer department in UL. • Compare Content Management Systems and HTML websites.	
7. Develop DSA.	• Develop the DSA in four phases; plan, design, construct and evaluate.	• Website Development Life Cycle • WordPress.com web development
8. Evaluate DSA.	• Evaluate DSA prototype with cooperating community for usability. • Evaluate DSA prototype with steering committee (EPA and An Taisce).	• Prototyping • Evaluation
9. Finalise DSA through modification.	• Modification of DSA based on feedback. • Web hosting.	• WordPress.org web development

Table 7: Research Roadmap of methods adopted to achieve objectives.

3.1 Development Process

The research roadmap indicates the entirety of research conducted. For the purpose of this chapter, the focus is on the development process of the DSA which is represented as objectives 7, 8 and 9. Figure 3 presents the stages of the development process which are described in the subsequent sections. In order to achieve objectives 7, 8 and 9, the development process was informed by a combination of System Development Life Cycle and Prototyping. The System Development Life Cycle approach is a sequential process beginning with identifying the system objectives that is the needs of the end users (White and Raman 1999; Avison and Fitzgerald 2003). However, sole employment of the life cycle approach poses limitations due to the lack of practical end user involvement (Budde *et al.* 1992). Therefore, a combined System Development Life Cycle and Prototyping approach was selected as the most suitable method because it provides a structured technique, therefore ensuring project consistency and completeness, with the importance of the end user highlighted. This hybrid combination is termed Web Development Life Cycle (French 2011). For the purpose of this project the Web Development Life Cycle was tailored to include plan, design, construct, evaluate and modify. The methodology has been described below under these headings.

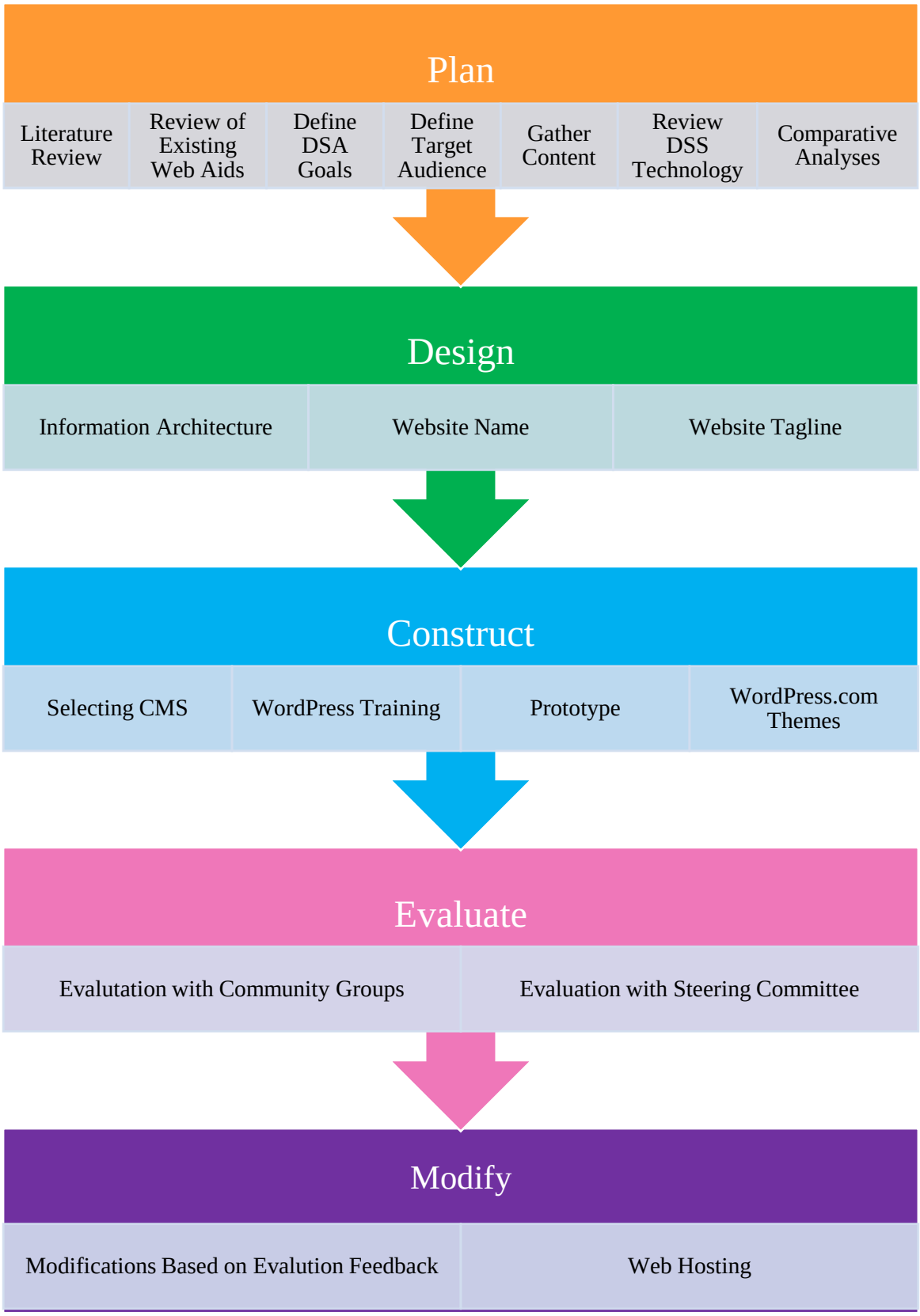


Figure 3: Development Process for creating the DSA.

3.1.1 Plan

The planning phase consisted of gathering information relating to sustainable communities in Ireland, existing environmental and sustainability web aids, DSA goals, target audience, content and practical platforms for development. It is important to note that objectives 1, 2, 3, 4, 5 and 6 as listed in Table 7, each contributed to the planning phase. Research was achieved through a literature review, evaluation of existing sustainability tools and comparative analysis of DSA platforms.

3.1.1.1 Literature Review on Sustainable Communities

A review of literature was undertaken at intervals throughout the project to create a solid theoretical base and a foundation for addressing the project aim. The review consisted of researching information from multiple sources including academic publications, websites, journal articles, conferences, books and workshops. In addition to building on work previously conducted in the Environmental Research Centre in the University of Limerick (Moles *et al.* 2006; Fitzgerald *et al.* 2012; O'Doherty *et al.* 2013; Byrne and O'Regan 2016; Byrne *et al.* 2017). The review of previous work contributed to the identification of multiple issues associated with progression of sustainable communities which influenced the content of the DSA.

3.1.1.2 Evaluation of Existing Sustainability Tools

An evaluation of existing sustainability tools with online availability was made based on their accessibility, usability, navigation, platform of development and content. The review revealed that there was a distinct knowledge gap in the provision of information relating to the setting up of a sustainable community in Ireland. It was difficult to find information on legal obligations, funding sources and planning permission inclusive from the same source. Additionally, the dissemination of such tools is greater in other countries such as America, Scotland and England (Community Places 2012; Community Tool Box 2018; Community Energy Plus 2019; Local Enegy Scotland 2019) which suggested that they were of value to communities.

3.1.1.3 DSA Goals

The overall purpose of the DSA was to disseminate information to the general public in order to aid progression of sustainable communities at the local level in Ireland. Through the literature review and evaluation of current environmental and sustainability aids, the principle goals of the DSA were identified:

- To provide basic information on what a sustainable community is and the benefits associated with sustainable living.
- To provide step by step information on how to set up a sustainable community.
- To provide detailed information on legal and financial matters in a simple user-friendly manner that is easy to navigate.
- To increase the awareness and knowledge of negative environmental impacts and how these can be mitigated at a local level.
- To provide clear information relating to possible community action projects which users could undertake.
- To provide Irish case studies of established sustainable community groups.
- To provide a list of working links to useful external resources.
- To evaluate the usability of the DSA with a cooperating community group.

In order to achieve these aims the DSA needed to be:

- Accessible
- User-friendly
- Accommodate text heavy content
- Easy to navigate
- Easily updated by non-technical personal

3.1.1.4 Target Audience

Successful product design constantly promotes end-user focused design (Redish 2012; Courage 2015). Paying careful attention to users helps create a website that delivers useful and helpful information in a functional format (Karlins and Sahlin 2019). Developers must accommodate a wide range of user preferences and capabilities (Skov and Stage 2012). In order to ensure all levels of understanding were accommodated three end user profiles were created (Redish 2012). Profiles are detailed descriptions of end users as individuals. User centred design suggests creating individual user profiles based on age, demographic, gender and personal interests from a pre-determined general target audience (Pruitt 2006; De Matos *et al.* 2013). The general target audience was any individual in Ireland, aged 18 or over, with an interest in becoming a member of a voluntary community with a focus on sustainable living. This was interpreted from a beginner, intermediate and advanced user perspective. The beginner user had no background in sustainable living and did not understand its importance in society. The objective was to increase awareness by

introducing the general concept of sustainability in an easy to understand manner and engage interest by providing a list of benefits associated with sustainable communities. The intermediate user was a keen environmentalist but did not understand how they could make an impact at the local level. Here the objective was to present how to set up a sustainable community and provide external links to useful resources. The advanced user was an existing member of a sustainable community group in Ireland that was struggling with further development due to legal and financial barriers. The objective was to identify and explain their legal options and funding sources in a comprehensive manner.

3.1.1.5 Content

The content has been considered the most important element of any information specific platform (Dawson 2010; Redish 2012) therefore, content needs to be addressed prior to design and construction. The content of the DSA was influenced by the literature review conducted on barriers to progression of sustainable communities, review of existing environmental and sustainability web aids and feedback from the steering committee.

The DSA builds on research previously conducted in the Environmental Research Centre in the University of Limerick (Byrne *et al.* 2017). The author found that individuals at the local level were driven by the desire to 'do the right thing' but saw legal obligations and lack of funding opportunities as a barrier to progression. Consequently, it was important that legal and financial information made up the primary content of the DSA. The multidisciplinary research team met bi-annually and maintained close contact through phone and email. The team included environmental consultants with expertise in finance, and a legal professional with a background in aiding sustainable communities. The information focused on appropriate legal structures for protecting community members, planning permission procedures for sustainable action projects and funding sources to aid development of community projects. The information gathered was content rich because there existed a wide variety of avenues community groups could take to gain legal status and obtain funding. Therefore, the DSA had to be capable of incorporating text heavy content.

Additionally, there needed to be an introduction to sustainable communities to encourage engagement. The most common barriers to engagement are lack of awareness and understanding of the importance sustainable development plays in a local community therefore awareness raising was an integral part of the DSA. The steering committee

meetings provided recommendation of content for this part of the DSA. The full list of content consisted of an introduction to sustainable communities and their importance, the UN sustainable development goals, case studies, community projects, legal status, funding sources, planning permission, gaining recognition, useful resources, glossary and a DSA manual. Each section has been described in detail below.

3.1.1.5.1 Introduction to Sustainable Communities

In order to incorporate all levels of understanding there must be a lead up to the comprehensive content. As the DSA is targeted at a varied general public, there was a necessity to define sustainable communities and highlight the benefits associated with them, as well as the motivations for people getting involved in the first place. Therefore, the section titled 'Get your Community Group Started' was created.

3.1.1.5.2 UN Sustainable Development Goals

The United Nations Sustainable Development Goals are part of the 2030 Agenda for Sustainable Development (UN 2015b). The Steering Committee recommended that a list of the 17 goals should be included to highlight the connection between community scale actions and policy.

3.1.1.5.3 Case Studies

Middleton (2018) pointed out that the sharing of success stories is an effective method to engaging individuals and enhancing sustainable growth. Stories inspire, are personal, relatable, create emotion and demonstrate growth. Therefore, the use of case studies was an important element of the DSA, so as to encourage engagement and involvement.

3.1.1.5.4 Community Projects

If users want to make use of the primary legal and financial content, they need a plan of community action. Community groups will be unable to obtain funding without creating a governance structure and devising a detailed plan. A community needs to discuss what they wish to achieve and define their mission and goals (BSI 2011). The inclusion of community actions provided users with a starting point to brainstorm ideas and make decisions on what actions are right for them, prior to taking on legal obligations and funding.

3.1.1.5.5 Legal Status

Legal structures relevant to a community group include partnerships, limited companies and co-operatives. The legal professional provided information on these aspects in terms of a definition, general information, documentation required and the advantages and

disadvantages of each (Hanratty 2019c). The content was formatted appropriately to aid readability and community characteristics were defined for each. Additional information was included on charitable status and social enterprises (Hanratty 2019b).

3.1.1.5.6 Funding Sources

The environmental consultants provided information on funding sources in Ireland, specific to community group projects, as listed below (McGarrity and O'Toole 2019).

1. Clann Credo
2. Climate Action Fund
3. Coillte
4. Community Finance Ireland
5. Donate as You Save Energy
6. Dormant Account Funding
7. Energy Agencies
8. Energy Cooperatives
9. International Fund for Ireland
10. LEADER
11. Local Agenda 21
12. National Lottery
13. REFIT
14. Renewable Heat Incentive
15. SEAI
16. Social Entrepreneurs Ireland
17. Social Innovation Fund
18. SSE Airtricity Community Fund
19. The Community Foundation for Ireland
20. The Ireland Funds
21. The Wheel
22. Town and Village Renewal Scheme
23. Triodas Bank
24. Údarás na Gaeltachta

Each funding source was represented with an overview, case study, technical explanation, contact details and website links to the original source of information. Content was reviewed and reformatted appropriately.

3.1.1.5.7 Planning Permission

Planning permission was identified as a paramount element of the content from previous research carried out by the Environmental team in UL (Byrne and O'Regan 2016; Byrne *et al.* 2017). Planning permission is important when taking on community projects, especially energy related such as wind turbines or solar panels (McLaren Loring 2007; Scannell 2011; Byrne and O'Regan 2016). The legal professional provided information on how to determine if a community project needs planning permission, steps to obtaining planning permission and a list of exempted developments (Hanratty 2019a). Content was reviewed and formatted appropriately.

3.1.1.5.8 Gaining Recognition

Measuring progress is an important factor to maintaining interest and encouraging action at a local level (Ferenhof *et al.* 2014). The ZECOS Project acknowledged the significance of measurement and verification of GHG emissions as both an incentive to action, and also inspiration towards further engagement in experienced community groups (ZECOS 2015). Therefore, a section on gaining recognition was incorporated and aimed at advanced users with experience in sustainable community development. Content included a list of sustainable management standards and links to external measuring tools.

3.1.1.5.9 Useful Resources

The web based DSA does not intend to provide an exhaustive list of information but rather guide users. The inclusion of links to other resources was imperative as to provide a knowledge warehouse of resources situated in the one place. The list of useful resources includes a summary of links to external information sources, which have been used throughout the website.

3.1.1.5.10 Glossary

The glossary was an essential part of meeting user friendly requirements. It was important to include definitions for technical terminology to ensure all levels of understanding were catered to.

3.1.1.5.11 DSA Manual

The DSA manual was a guide on how to navigate and use information on the web based DSA. The inclusion of navigation instructions was an imperative element to promoting ease of use. It was highlighted as a positive attribute throughout existing environmental and sustainability web aids. To ensure a general understanding the DSA manual was presented as the 'Help' section of the website.

By addressing the description of content prior to construction it was easier to direct the design of the web based DSA for the subsequent section.

3.1.1.6 Critical Review of DSS Technology

A critical review of DSS and development methods was undertaken through review of books and journal articles where an understanding of traditional DSS was gained. The review revealed that there are numerous issues associated with disseminating information to the wider public using a traditional DSS (Papathanasiou and Kenward 2014; Zulkafli *et al.* 2017). DSS technology is generally aimed at management level in a specific organisation, meaning the target audience is smaller than the intended target audience for this project's development. When designing a DSS it is of the utmost importance to keep the end user in mind at all aspects of development (Díez and McIntosh 2009). Therefore, as the end user differs drastically alternative development methods were considered. Additionally, many of these DSSs dealt with what if scenarios and algorithms which were beyond the scope of the content used in this project.

DSS may be developed on various platforms as long as they support data storage, data analysis, solution method development and graphical user interface (Dous *et al.* 2018). As the model component is unnecessary in relation to the content, options were explored which accommodated a user interface and a database element. In order to identify the most suitable platform for delivery of content, different types of decision support technology were researched based on their ability to fit the desired criteria of the DSA. Spreadsheet based and web based platforms were identified as alternatives to traditional DSS as they support accessibility, easily updated content and a modifiable database and user interface.

3.1.1.7 Comparative Analysis of Spreadsheet and Web Based DSA Platforms

The rationale for selecting a web based platform followed the results of a comparative analysis of spreadsheet and web based platforms with additional consultation involving members of the electronic and computer engineering department in the University of

Limerick. Both methods provided a strong case for a web based platform. The platforms were compared on accessibility, user interface appearance, ability to accommodate text heavy content, navigation and how easily updated the platform was.

3.1.1.8 Comparative Analysis of CMS and Website from Scratch

A comparative analysis was also carried out on methods to build the web based DSA. The primary options were a content management system or build the website from scratch using code and database connectivity with an online server. Methods were analysed based on learning curve (technical and design skills), appearance, maintenance, time and cost. Research revealed that incorporation of a CMS was optimal for the purpose of this project as it satisfied the DSA development requirements.

3.1.2 Design

Design of the DSA involved structuring the content in an easy to navigate and methodical manner, identifying a memorable website name and tagline and creating a specific look and feel for the DSA. Research was conducted on how to design a user centred website with emphasis on user experience design. Additionally, information and knowledge were gained through attendance of relevant training courses such as 'Writing for the Web'.

3.1.2.1 Information Architecture

Information architecture refers to the structuring, categorising and organising of content in a logical easy to understand manner (Morville and Rosenfeld 2006). The structure of the DSA was determined once the content was created and reviewed for readability. Dawson (2010) suggested a simplified process of dealing with information architecture for the successful design of a website:

1. Categorise content into grouped site sections.
2. Produce a sitemap to represent the hierarchy and links between each grouped section.
3. Create a wireframe to exemplify the sections of the landing page, pathway pages and information pages.

This process was adopted to design a graphical representation of the DSA. The theoretical graphical represented design may change based on the practical implementation of the DSA in the construction phase.

3.1.2.1.1 Categorisation of Content

To avoid information overload and simplify the process in which users navigate and locate information, content was categorised into sections. As discussed previously, the content consisted of an introduction to sustainable communities, the UN sustainable development goals, case studies, community projects, legal status, funding sources, planning permission, gaining recognition, useful resources, glossary and a DSA manual. The content was divided based on the target audience user profiles. The sections needed to accommodate the beginner, intermediate and advanced user. Introduction to sustainable communities, the UN Sustainable Development Goals and case studies were categorised as 'First Things First' because each area was most applicable to a beginner user. Further work was undertaken to develop themes for community actions and funding sources in order to break up extensive information into smaller groups. Examination of targets as set out by the Irish Environmental Protection Agency (EPA) provided a guide to the range of topics to be included. The most recent EPA assessment report, '*Ireland's Environment 2016 – An Assessment',* focused on several areas including climate change, nature, inland and marine waters, waste, land and soil, transport and energy (EPA 2016). Additionally, literature highlights several overarching themes amongst transition movements and sustainable communities to be food, energy, water, transport, ecology and sustainable modes of production and consumption (Clark 2010; Markard *et al.* 2012; Feola and Nunes 2014). For this reason, six community themes were chosen to represent community actions at the local level and funding sources: Energy Efficiency, Food, Renewable Energy, Transport, Waste and Water. Legal status, planning permission, useful resources, gaining recognition and the DSA manual contained less content and were not applicable to the community themes therefore they remained as separate isolated sections. Within each section subcategories of content were created. In order to show users the main content at a glance, the primary sections were represented by the primary navigation menu of the website, while the sub categories were represented by the secondary drop down menus (Dick 2017).

3.1.2.1.2 Sitemap and Decision Stages

Layout models have been recognised as highly effective in allowing developers to create a visual representation of the website structure (Dawson 2010). This step promotes consistency of web pages which increases scannability and therefore readability. The content was text heavy with multiple layers of information, hence a hierarchical website layout was incorporated and graphically represented prior to development. This was

selected as the most suitable for disseminating specific information where the information becomes more detailed as the user works through the website (Lynch and Horton 2008). The sitemap begins with the Homepage and has branches connecting it to other pages, similar to a decision tree. Each branch represents a page that users can reach by clicking on an internal link. The sitemap also indicates the decision stages of the website. At first the user is provided with multiple options to choose from which appear on the primary menu. Once the user selects an option, they are either brought to the final information page or a pathway page. The pathway pages provide more options based on their initial decision. Each option is described briefly on the pathway page in order for the user to make an informed decision on which category they want to explore further. The destination pages display detailed information and links to retrieve further knowledge from external sources, therefore delivering another decision to the user on whether to explore the topic in more detail from the original source. For the purpose of this project several sitemaps were created to signify the levels of content and the decision stages. Figure 4 displays the overall navigation process of the web based DSA with green signifying the landing page, blue signifying the primary navigation menu and decision stage one, and pink signifying the secondary menus and decision stage two.

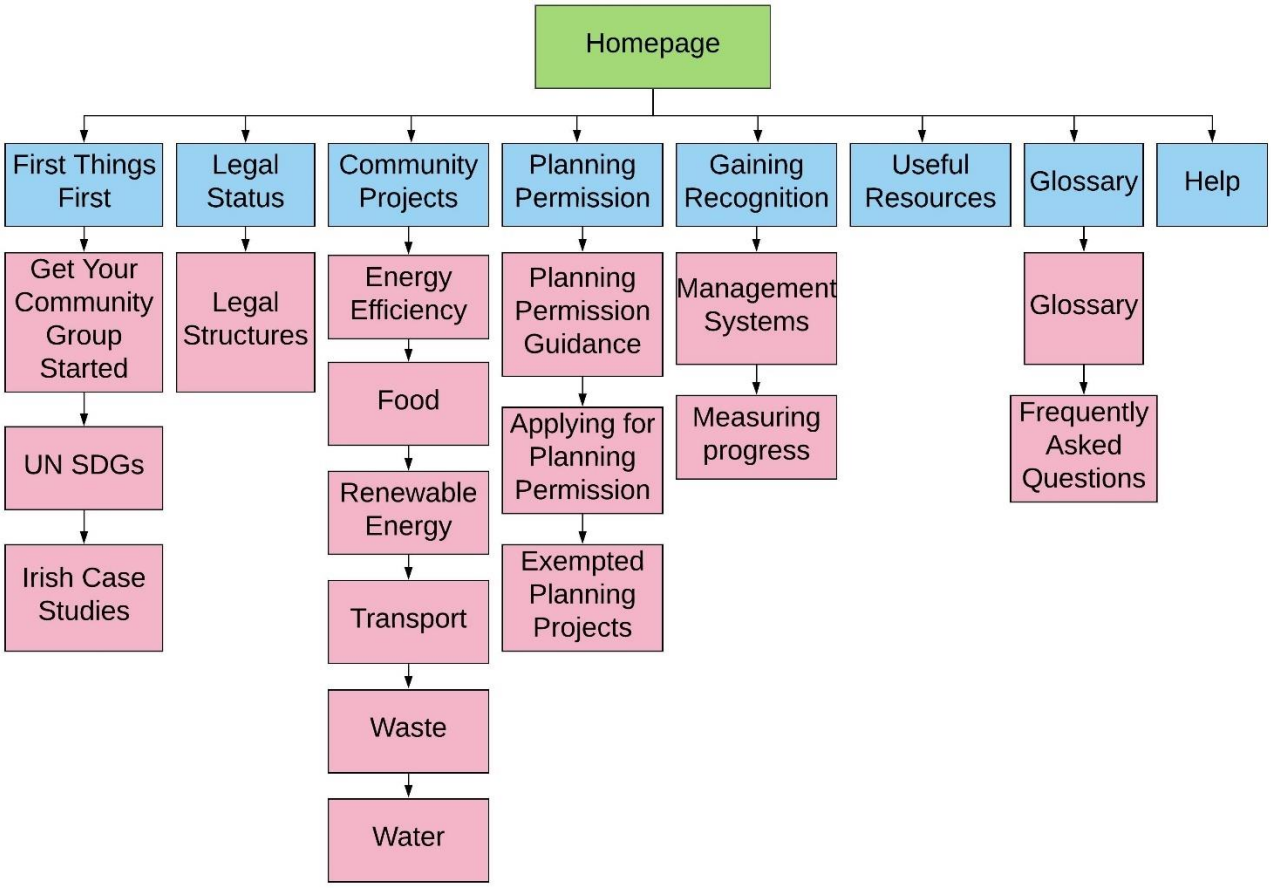


Figure 4: Sitemap displaying the primary menu and secondary dropdown menus.

Figure 5 indicates the navigation process of legal content with purple representing decision stage 3 and the pathway pages, and darker purple representing the destination pages containing detailed content. The user is provided with a brief description on the pathway pages of each legal structure in order for them to make an informed decision, while avoiding information overload. Figure 6 presents navigation for community project and funding sources content where the colours are represented in the same manner as Figures 2 and 3. Here the pathway pages are the community themes therefore they provide more content than the legal pathway pages. Community actions relevant to each theme are explained and a link to access funding sources associated with each is provided.

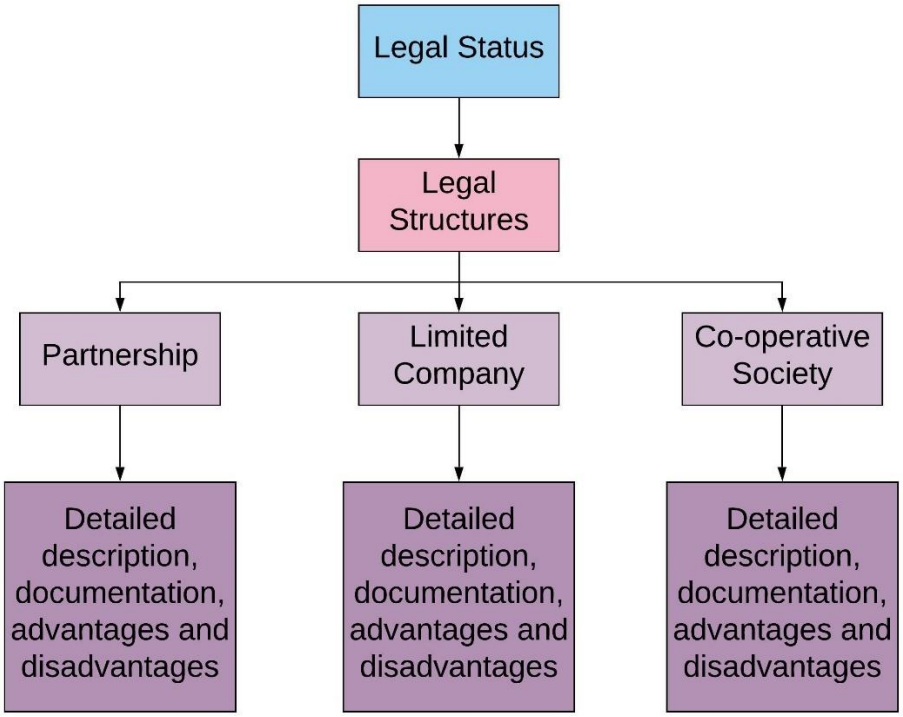


Figure 5: Sitemap indicating navigation and decision stages of legal status content.

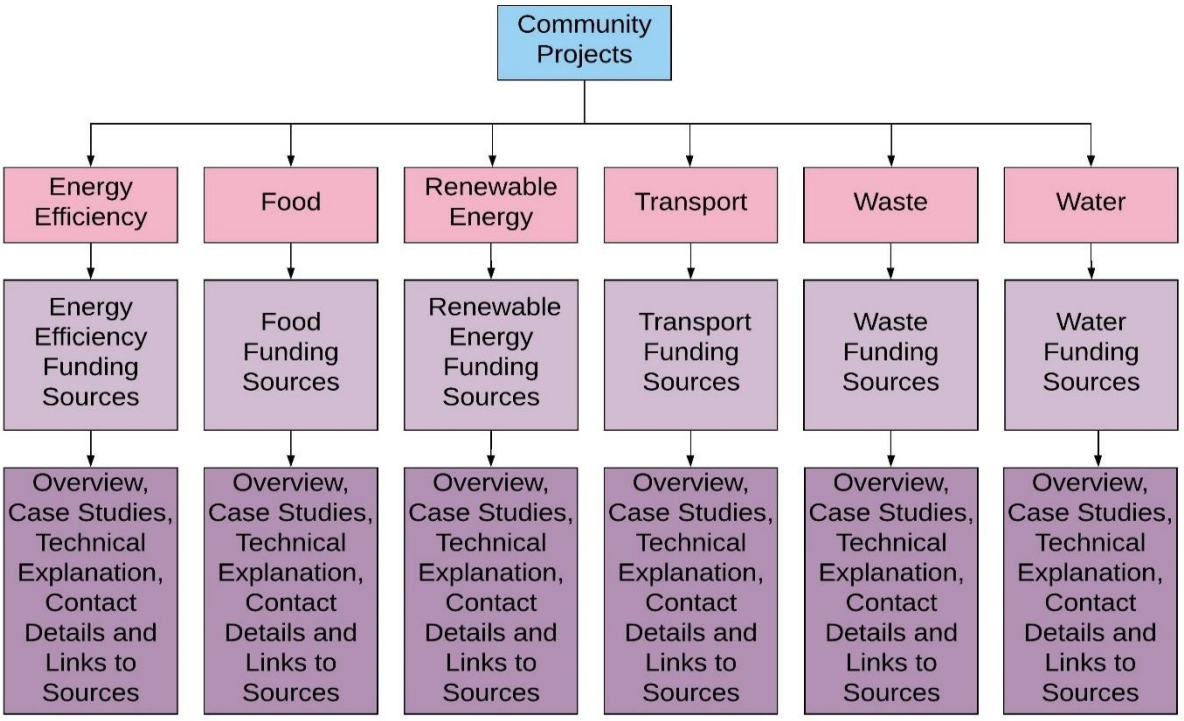


Figure 6: Sitemap indicating navigation and decision stages of community projects and funding sources content.

3.1.2.1.3 Wireframe

Wireframing concentrates on the arrangement of visual elements displayed on the web page. It incorporates features such as logo, tagline, search box, primary/secondary menus, social links, news articles, media, header, footer and links to further content (Dawson 2010). For the purpose of this project multi wireframes were created, as it was discussed with the research group and steering committee, that not all webpages would be identical. For example, the home page was different to the destination pages. Figures 7, 8 and 9 present several options of Homepage design. Figure 6 was chosen because it abides by user focused design principles by allowing content to appear above the fold, incorporating a clear representative image and ensuring a stark contrast between letters and background colour to enhance readability.

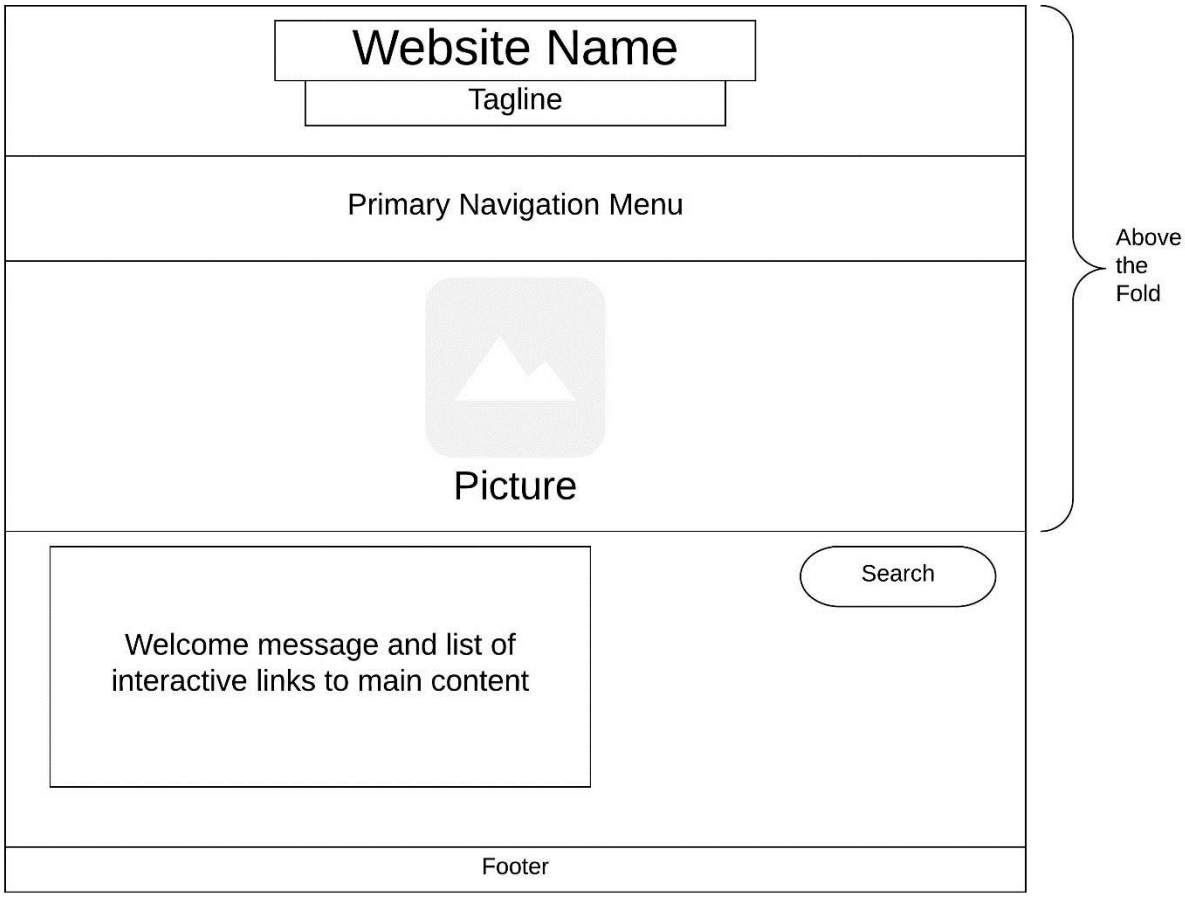


Figure 7: Wireframe option number one for Homepage design.

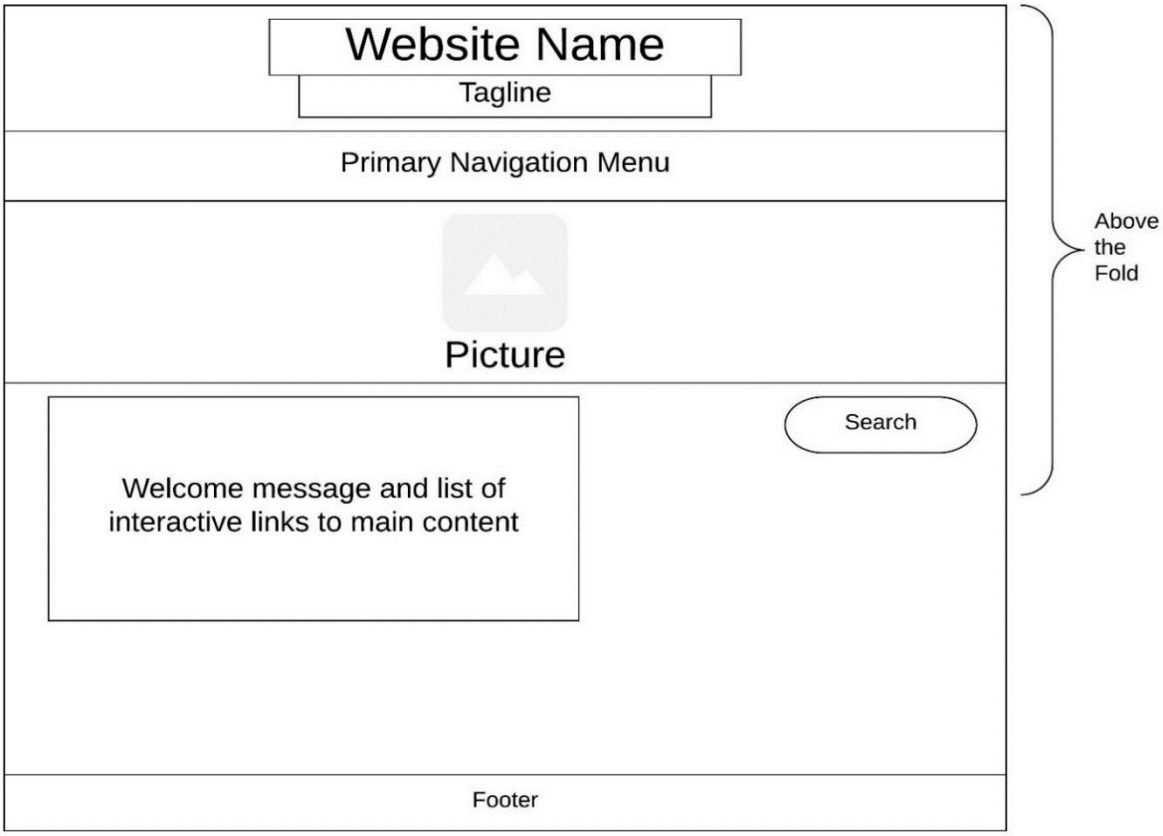


Figure 8: Wireframe option number two for Homepage.

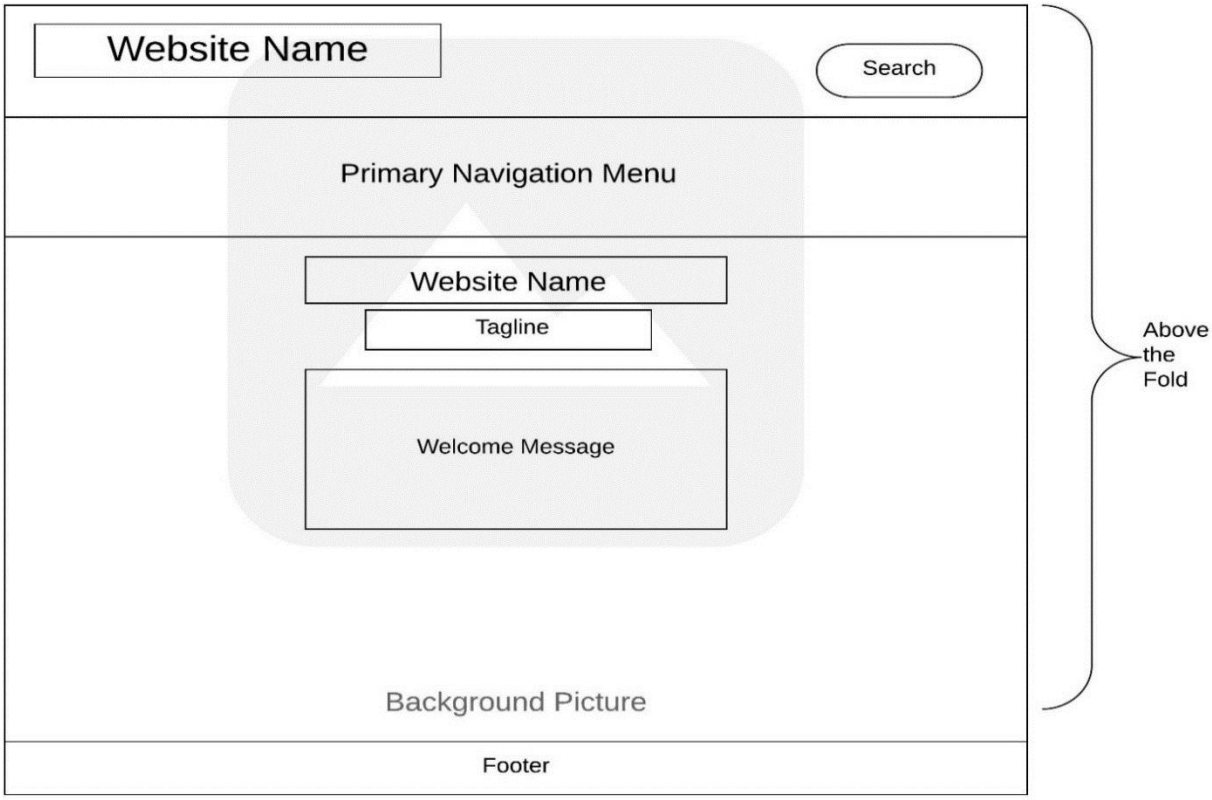


Figure 9: Wireframe option number three for Homepage.

Figure 10 displays the visual design of a generic destination page. Destination pages contain the largest amount of content therefore it was important to break up text using larger headings, short paragraphs, bullet points and strategically placed active white space. Pathway pages were outlined in the same format as destination pages to ensure a consistent layout, however content was less dense.

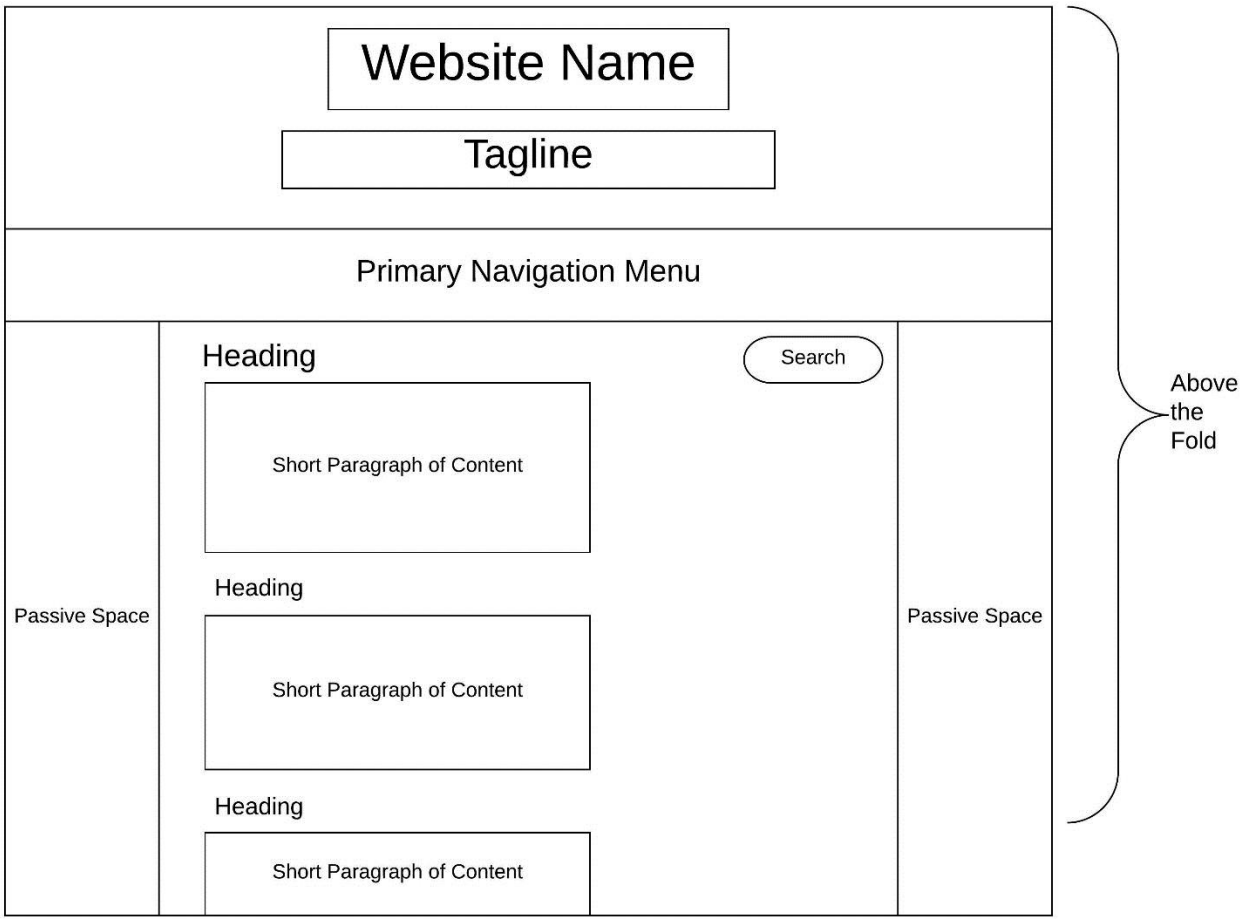


Figure 10: Wireframe for Information/Destination pages.

3.1.2.2 Website Name

The domain name of a website should be short, memorable, easy to spell and recognisable (Heng 2011; Whitson 2012). The website name must also be representative of the content it provides and avoid numbers, hyphens and complicated words (Benjamins 2019). The following domain names were considered:

- SUDcommunities.ie
- Besustainable.ie
- Oursustainablefuture.ie
- Localsustainability.ie
- Sustainablecommunities.ie

- Supportingsustainablecommunities.ie
- Simplysustainablecommunities.ie
- Helpingsustainablecommunities.ie

The use of .ie domain extension was considered essential as the information provided is specific to Irish communities. Through deliberation with the steering committee and research team, a consensus was reached that 'sustainablecommunities.ie' was the most appropriate domain name as it represented the purpose of the website, was clear, short and easy to remember.

3.1.2.3 Website Tagline

A website tagline is a concise statement of the websites purpose, generally between 6-8 words in length (Schwartz 2013). The following taglines were reviewed:

- Simple sustainability at a local level
- Learn to live sustainably
- Creating sustainable communities from the ground up
- Smart sustainable knowledge at a local level
- Be informed, be inspired, be sustainable
- Empowering communities to reshape their future
- Platform of knowledge to support community sustainability

It was determined that 'Empowering communities to reshape their future' was the most appropriate as it signalled a call to action, and highlighted that responsibility was with the local individual.

3.1.3 Construct

The construction phase of the development process entailed selecting the most suitable content management system (CMS), obtaining relevant training on the chosen CMS, populating the web based DSA with content to create the prototype and reviewing the final form for spell checks, grammar and working links.

3.1.3.1 Selecting CMS

WordPress, Joomla and Drupal were analysed based on learning curve, support, functionality and cost. The decision was guided by the DSA criteria. For the purpose of this

project, the CMS needed to be straight-forward to facilitate regular updating of content by the environmental team, accompanied by extensive help and support in the form of handbooks, online forums, tutorials and courses, contain extended features to accommodate the pre-determined design layout and low cost to remain within budget. Consequently, WordPress was chosen as the most appropriate CMS because it provides the greatest functionality with maximum ease of use. There are a wide variety of free pre-built templates and plugins to accommodate the design layout in addition to numerous help and support comprising of online courses for beginner and advanced users.

3.1.3.2 WordPress Training

Information and knowledge were gained through an online course offered by Udemy entitled 'WordPress for Beginners – A Complete Guide to WordPress' which demonstrated the set-up of a WordPress.org website using 89 lectures. WordPress.org provides greater functionality than WordPress.com. While a WordPress.com website is easier to assemble and free conditional of the chosen plan, WordPress.org offers an added professional appearance, greater control over content and ability to track user numbers with google analytics (Jones and Farrington 2011). Subsequently, the prototype was developed on WordPress.com in order to ensure user input and steering committee evaluation prior to the final development. Furthermore, this allowed more time to consider web hosting, as WordPress.com could be made available to users online without payment of hosting. The final version was built on WordPress.org in order to create a professional end product with greater functionality.

3.1.3.3 Prototype

Prototyping is considered an essential approach to constructing high quality websites (Nieveen 1999; Lim *et al.* 2008; Benyon 2010; Sieber *et al.* 2013). A prototype is an initial interactive model of a system design which partially represents the end product (Benyon 2010). The rationale of prototyping is to evaluate the main design elements such as content, visuals, interactivity, functionality and media prior to implementation (Benyon 2010). For the purpose of this project a high fidelity prototype was developed as opposed to a low fidelity prototype. A high fidelity prototype is similar in functionality and design to the final product. It is created using software within the development environment of the final form and is therefore more advanced than low fidelity prototypes, which are generally constructed on paper (Benyon 2010). High fidelity prototypes are associated with increased validity of user feedback because they are similar in look and feel to the anticipated end

product, therefore evaluation is more detailed (Rosson and Carroll 2002). The prototype was developed using WordPress.com and set up online as www.sudtool.wordpress.com. The professional domain name chosen in the design stage was retained for the finalised version.

3.1.3.4 WordPress.com Themes

WordPress.com offers one hundred free pre-built design templates called themes. These were explored based on adherence to the multi wireframes created in the design stage. The most relevant included Sela, Gateway, Twenty Thirteen and Twenty Seventeen. It was founded that Sela was the most suitable, as the home page incorporated imagery similar to the location on the wireframe ensuring content appeared above the fold, preventing the creation of a false bottom (Redish 2012). Additionally, it allowed for the greatest functionality in relation to colours, navigation menus and positioning of search bar.

3.1.4 Evaluate

Evaluation took the form of a two-step approach. Firstly, the prototype was evaluated with two community groups in Ireland using an evaluation form. Secondly, it was reviewed by the project steering committee through an online demonstration presented by the researcher. Previous work in the field of evaluation and assessment of websites provided a basis for the assessment framework (Darejeh and Singh 2013; Garett *et al.* 2016).

3.1.4.1 Evaluation with Community Groups

In order to examine the web based DSA, an evaluation form was sent to two existing communities accompanied by a link to the prototype DSA website. Each community was given a month to review the prototype. The evaluation form was designed with the aim of assessing the effectiveness of the DSA prototype for disseminating relevant content to the local level in an easy to understand manner. The DSA was reviewed based on ease of navigation, usefulness of content, language used, accessibility and whether the website was suitable for non-experienced and experienced community groups. The evaluation form consisted of four closed ended questions, three of which were rating scale questions, and one additional open ended question. Comment boxes were also provided.

3.1.4.2 Evaluation with Steering Committee

The DSA prototype was reviewed at the final steering committee meeting on the 2nd October 2018. The Steering Committee consisted of two representatives from the EPA and

one from An Taisce. Table 8 details their research backgrounds which make them suitable candidates to provide feedback on the sustainability focused web aid.

Name	Job Title	Research Background
Dr. Dorothy Stewart	Scientific Officer, Research Sustainability and Innovative Water Research Projects Management, EPA.	• Sustainable urban town planning • Encouraging sustainability at local level through An Taisce Green Home programme
Dr. Shane Colgan	Senior Manager, Resource Efficiency Unit, EPA.	• Food processes and environmental issues • Sustainable environment • Environment and health
Dr. Damien Ó Tuama	National Cycling Coordinator with Cyclists.ie (Irish Cycling Advocacy Network) and An Taisce (The National Trust for Ireland).	• Sustainable transport • Cycling policy • Urban bike sharing • Mobility systems • Vice-President of the European Cyclists' Federation

Table 8: Summary of Steering Committee Members and their research backgrounds.

The prototype was presented by the researcher and each web page was assessed individually through a demonstration. The assessment was based on appearance, functionality, navigation, scope of content, and usability.

3.1.5 Modification

Several modifications were required based on response from the evaluation stage. The prototype was rebuilt on WordPress.org which allowed for the necessary modifications to be made. Further training of WordPress.org was carried out in order to incorporate greater functionality and a clear decision support element with a contiguous journey towards sustainability. Additional revisions were made to the content, navigation and appearance and several of the information pages were rewritten.

3.1.5.1 Web Hosting

Once the evaluation stage was complete it was possible to purchase web hosting. Several web hosting services were reviewed including Bluehost, Hostgator, Siteground and Hosting Ireland. Hosting Ireland was considered the most appropriate service to use because it provided the option to purchase a .ie domain name, along with hosting and WordPress installation. Additionally, there was comprehensive customer service with quick email response and website back up options.

4 Results

This section presents the results obtained from the development process of the web based DSA. Results comprise prototype design, feedback evaluation of prototype, modifications based on evaluation and discussion of modifications and redesign with description of the resulting finalised web based DSA. Figure 11 summarises the steps involved in the Results Chapter. The subsequent sections are detailed in the same layout. Section 4.1 outlines the original prototype design including screenshots. The evaluation feedback is then presented in Section 4.2, followed by a summary of the modifications in Section 4.3. It is important to note that the modifications were based on the evaluation feedback provided by the communities and Steering Committee. The discussion of resulting modifications and final design are depicted in Section 4.4.

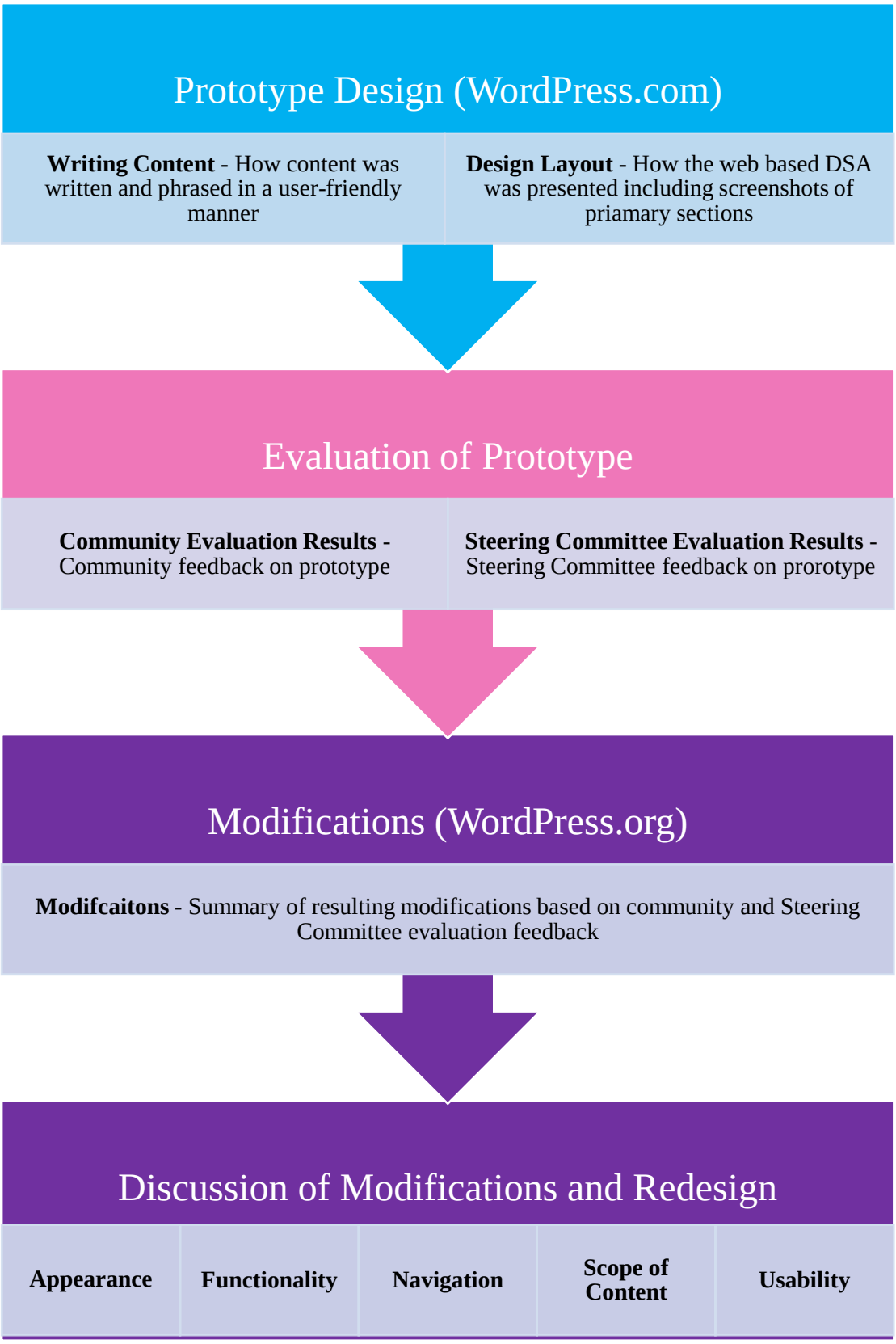


Figure 11: Steps involved in the Results Chapter.

4.1 Prototype Design

Through a comparative analysis of content management systems as detailed in Section 2.4.8, it was identified that WordPress was the most suitable platform for development of the DSA. For the purpose of the prototype, WordPress.com was utilised in order to allow for delivery of content at the local level without commitment of web hosting and purchasing of domain name prior to evaluation. Therefore, the prototype was less functional than the intended final form but suitable for evaluating content, accessibility and ease of navigation. Content was influenced by a literature review on sustainable communities, review of existing environmental and sustainability web aids, identification of DSA goals and research of target audience as outlined in Section 3.1.1, the plan stage. Content was structured using an information architecture technique suggested by Dawson (2010), which consisted of categorisation of content, assembly of sitemaps and design of wireframes as detailed in Section 3.1.2.1. A WordPress template, called Sela, was chosen based on the adherence of design elements to the projects predetermined layout. The content was reviewed for spelling, grammar and functioning links. The resulting prototype has been described below using image screenshots of the primary sections.

4.1.1 Writing Content

Through review of literature, as detailed in Section 2.5.1, several guidelines to writing user centred content were identified, which were employed when writing and reviewing content for the website. Content was written in a user friendly, engaging manner, similar to a conversational tone (Redish 2012). The use of headings, short paragraphs, bullet points, lists and left justification of text, were incorporated to break up text and increase scannability (Hassan and Li 2005; Schmidt 2011; Lee and Kozar 2012; Garett *et al.* 2016). Contrasting colours for text and background were selected to ensure content was easy to read. Headings were typed in larger and bold font to guarantee distinction, while internal and external links were written in text format making them more readable.

4.1.2 Design Layout

The design layout was developed in several stages beginning with categorisation of content, construction of sitemaps and establishment of wireframes as shown in Section 3.1.2.1. Extensive research of user interface design and consultations with several members of the Electronic and Computer Engineering and Computer Science and Information Systems departments in the University of Limerick, concluded that a hierarchy web layout was the

most suitable with integration of a horizontal navigational bar positioned at the top of the website, as shown in Figure 12 (Murano and Lomas 2015). This allowed for simplistic navigation with promotion of human-computer interaction and ease of use. Inclusion of imagery was perceived as a central asset to set the tone and feel of the website while increasing scannabilty (Redish 2012). The tagline 'Empowering communities to reshape their future' was linked to the Homepage image of a glass ball looking into a bright sunny future on a bicycle. The image also reflects the environmental aspect of the website with sustainable transport portrayed by the bicycle. A search facility was made available on the top right of each individual page to guarantee users could retrieve desired information quickly (Lee and Kozar 2012; Redish 2012; Garett *et al.* 2016). Green was chosen for the navigation menu colour and interactive links because of its connection with the environment and nature. Blue was used for the background colour because of its subtle association with trust and loyalty. It is one of the most popular colours in web design as seen on Facebook, PayPal and multiple online banking websites (Patel 2019). The categories of content identified from the design stage and developed in the construction phase of methodology, have been described below focusing on the resulting design layout.

4.1.2.1 Homepage

The Homepage introduces users to the website, therefore influencing bounce rate significantly. Bounce rate refers to the percentage of users that navigate away from a website after only visiting the landing page (Vecchione *et al.* 2016). Redish (2012) suggests several recommendations for an effective Homepage. The Homepage needs to convey the purpose of the website immediately by making it clear what the website has to offer through use of short descriptions, bullet points and links which allow users to start key tasks immediately. Additionally, it is imperative to avoid the creation of false bottoms by ensuring content is seen above the fold as to incentivise users to scroll down the page. For these reasons, the Homepage contained a short welcome paragraph outlining who the website was aimed at, the purpose of the website and a list of the main content with interactive links. A screenshot of the Homepage can be seen in Figure 12.

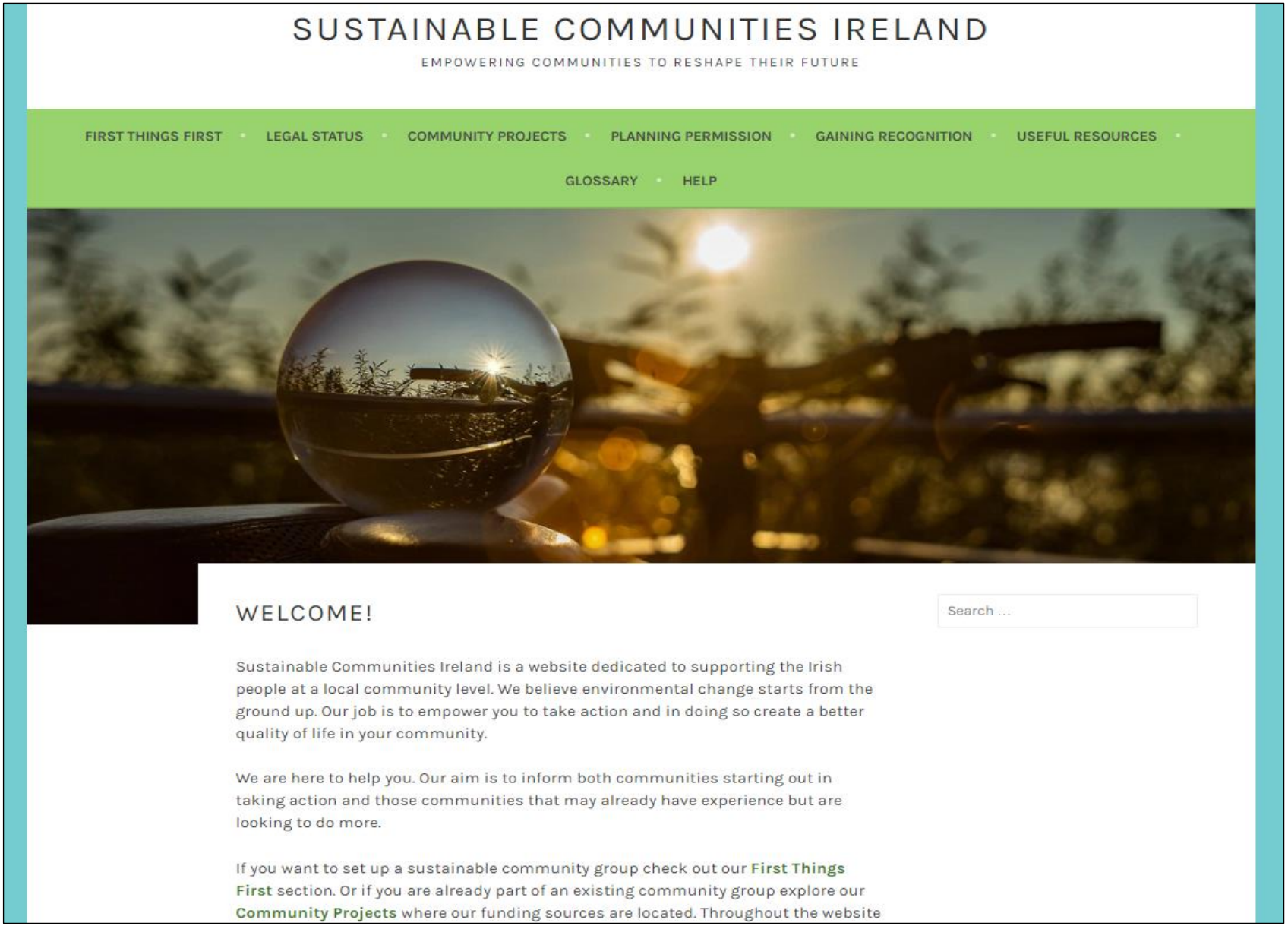


Figure 12: Screenshot of Homepage user interface.

4.1.2.2 'First Things First'

'First Things First' incorporated the awareness raising aspect of the web based DSA. It was aimed at beginner users and contained information pages on how to get started, the UN Sustainable Development Goals and Irish case studies. Information was sourced from the British Standards Institution's Micro Guide for developing sustainable communities (BSI 2011). The general appearance of information pages remained the same to stimulate consistency and allow users to develop usage patterns. However, in some cases, where information was dense, a table structure was incorporated to compartmentalise information and aid usability. Figure 13 displays the general appearance of information pages with 'Get Your Community Group Started', while Figure 14 reflects a table structure used to describe the case studies.

Figure 13: Screenshot of destination page 'Get Your Community Group Started'.

ECO MATTRESS RECYCLING

Search ...

Organisation Type	Social Enterprise
Established	2013
Location	Glasnevin, Dublin 11, in a facility provided by Dublin City Council
Environmental Action	Waste : Mattress Recycling
Purpose	Associate organisation of Sunflower Recycling to provide hands on work experience to specific groups including the long-term unemployed, those with addiction problems, and mental health issues
Legal Structure	Company Limited by Guarantee without Share Capital
Management Structure	A volunteer board of management whose members do not benefit financially from the business Functional management by two paid supervisors with administrative back up from Sunflower Recycling
Funding Sources	Initial capital expenditure provided by Sunflower Recycling Service charge paid by clients, supplemented by selling recovered metal

Overview

Eco Mattress Recycling is a sister organisation of Sunflower Recycling. The organisation's stated mission is to provide valuable work experience to their target groups through the prevention of waste mattresses being sent to landfill. Their main goals being the building of a sustainable business and the employment of a full-time workforce.

Figure 14: Screenshot of destination page 'Eco-Mattress Recycling' case study.

4.1.2.3 'Legal Status'

'Legal Status' covered an extensive amount of technical information relating to legal opportunities for community groups. Information was sourced from the research team's legal professional (Hanratty 2019c). Content was reviewed and reformatted to optimise readability and comprehension by users. There was a brief introduction page added explaining the meaning of legal status in relation to community groups and the associated benefits. Users were then guided to a pathway page of legal structures as displayed in Figure 15. Each legal structure was introduced using a brief description and list of applicable community characteristics, with the intention that users would make an informed decision on which legal structure suited their community best. Each item was interactive, therefore users could click on the description to access the final destination page containing the full comprehensive content. This approach abides to the hierarchical web layout outlined in Section 3.1.2.1. Initially users were provided with straight forward basic information which became more detailed as they worked through the website making decisions. Each destination page was laid out in the same manner with similar placement of headings to promote consistency and break up text. Headings included a general description, documentation required, types of members needed, advantages and disadvantages. An example of the 'Limited Company' destination page can be seen in Figure 16.

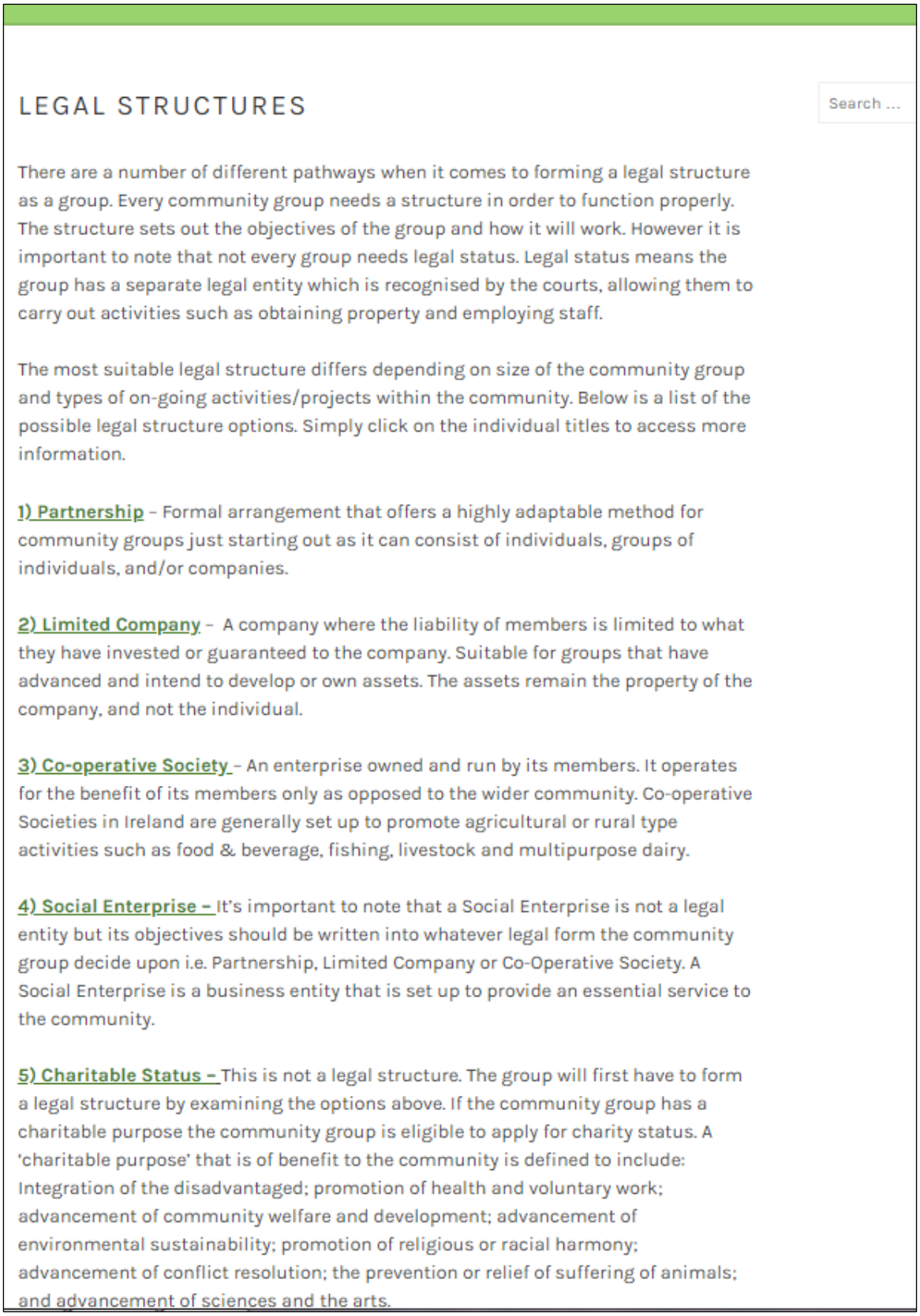


Figure 15: Screenshot of destination page 'Legal Status'.

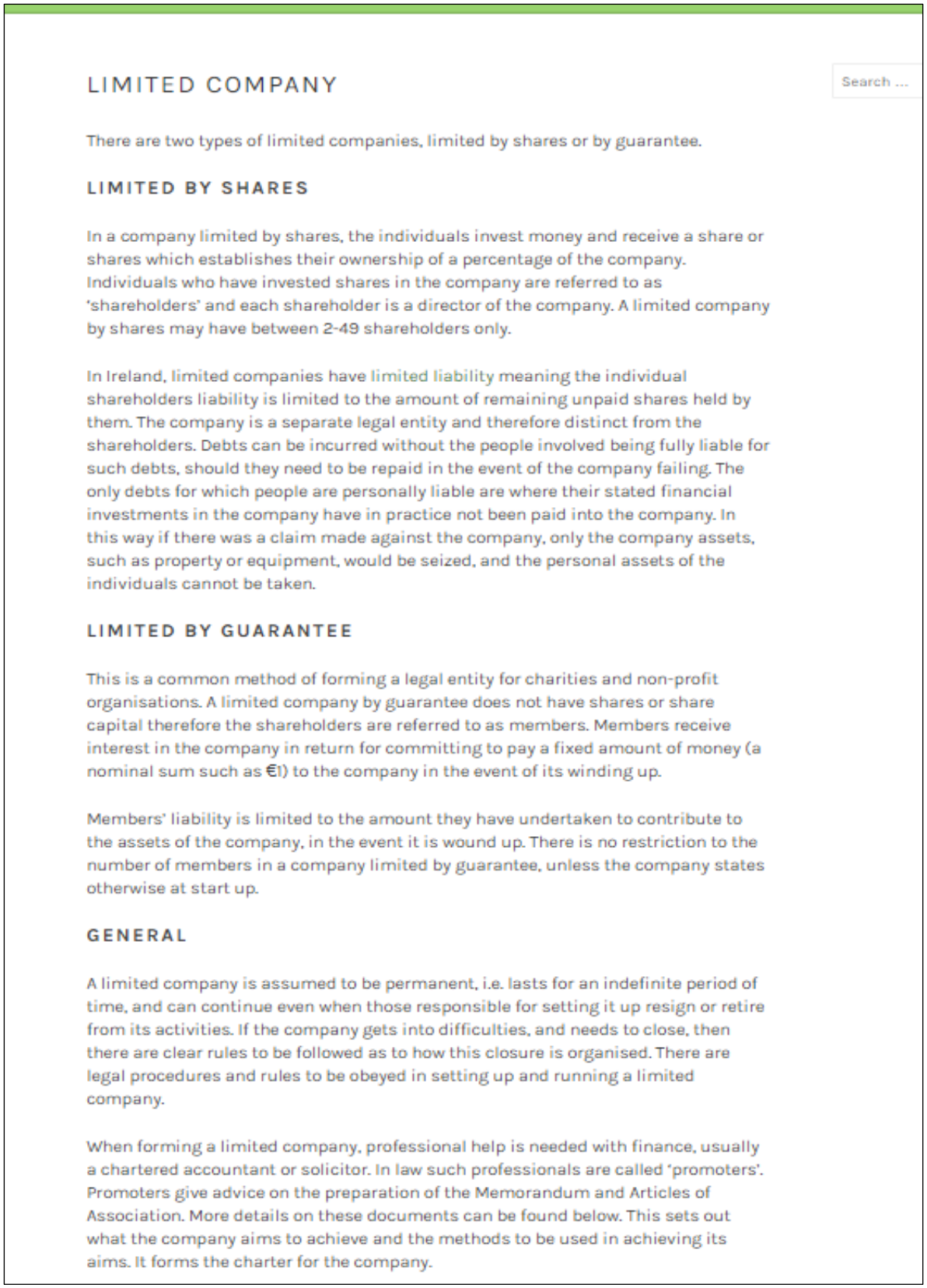


Figure 16: Screenshot of destination page 'Limited Company'.

4.1.2.4 'Community Projects'

In Section 3.1.1.5, during the 'plan' stage of methodology, it was determined that inclusion of community projects would be an asset to the DSA because it encourages groups to devise a plan of action which is necessary when applying for funding (BSI 2011). Furthermore, a greater understanding of sustainable communities is achieved by addressing different aspects of sustainable development. As detailed in Section 3.1.2.1.1, through a review of literature and relevant government documents six overarching themes were selected to categorise community projects; 'Energy Efficiency', 'Food', 'Renewable Energy', 'Transport', 'Waste' and 'Water'. Each theme was divided among three headings; Theme Name, Personal Action and Community Action. It was important to include personal actions as well as community actions to increase overall awareness from a homeowner's perspective too. Additionally, personal actions could be used to initiate discussion at meetings. Links to external sources were available throughout the webpage allowing users the option to access further information from the original source. Figure 17 indicates the layout of the 'Food' destination page. In order to support greater usability, the layout remained consistent for each theme using bullet points and numbered lists to describe the actions, and a general introduction highlighting their relevance in a sustainable community. Additionally, there was a link to access funding sources at the bottom of each webpage.

FOOD

Search ...

Food is an essential part of our everyday lives. But how many of us actually understand where our food comes from? In recent decades food has taken over on an industrial scale, creating a barrier between people and food. The distance food travels has a huge impact on the environment as the further afield it is the greater energy consumed and CO_2 released.

Additionally industrial farming impacts animal welfare, landscapes, wildlife, food quality and human health. Food imports are necessary to ensure certain foods are available all year round, however the scale at which food is being imported is unnecessary. We as consumers have the power to make a difference by buying more locally grown produce.

The overall aim is sustainable food i.e. food that is produced in a way that reduces energy consumption and contributes to the improvement of the environment. The emphasis is on local products and reducing food miles (total distance in miles the food has been transported, from field to plate).

Calculate your food miles here!

PERSONAL ACTION

As an individual you have the choice to shop locally. This can be done through farmers markets or simply inspecting packaging in the supermarket. For example if you see the Bord Bia Quality Mark then you know it is of Irish origin. Shopping locally reduces food miles greatly. A list of local markets can be found through the links below.

List of country markets.

List of farmers market.

Additionally you could grow your own fruit and vegetables in your back garden. See the Grow It Yourself website for further information.

COMMUNITY ACTION

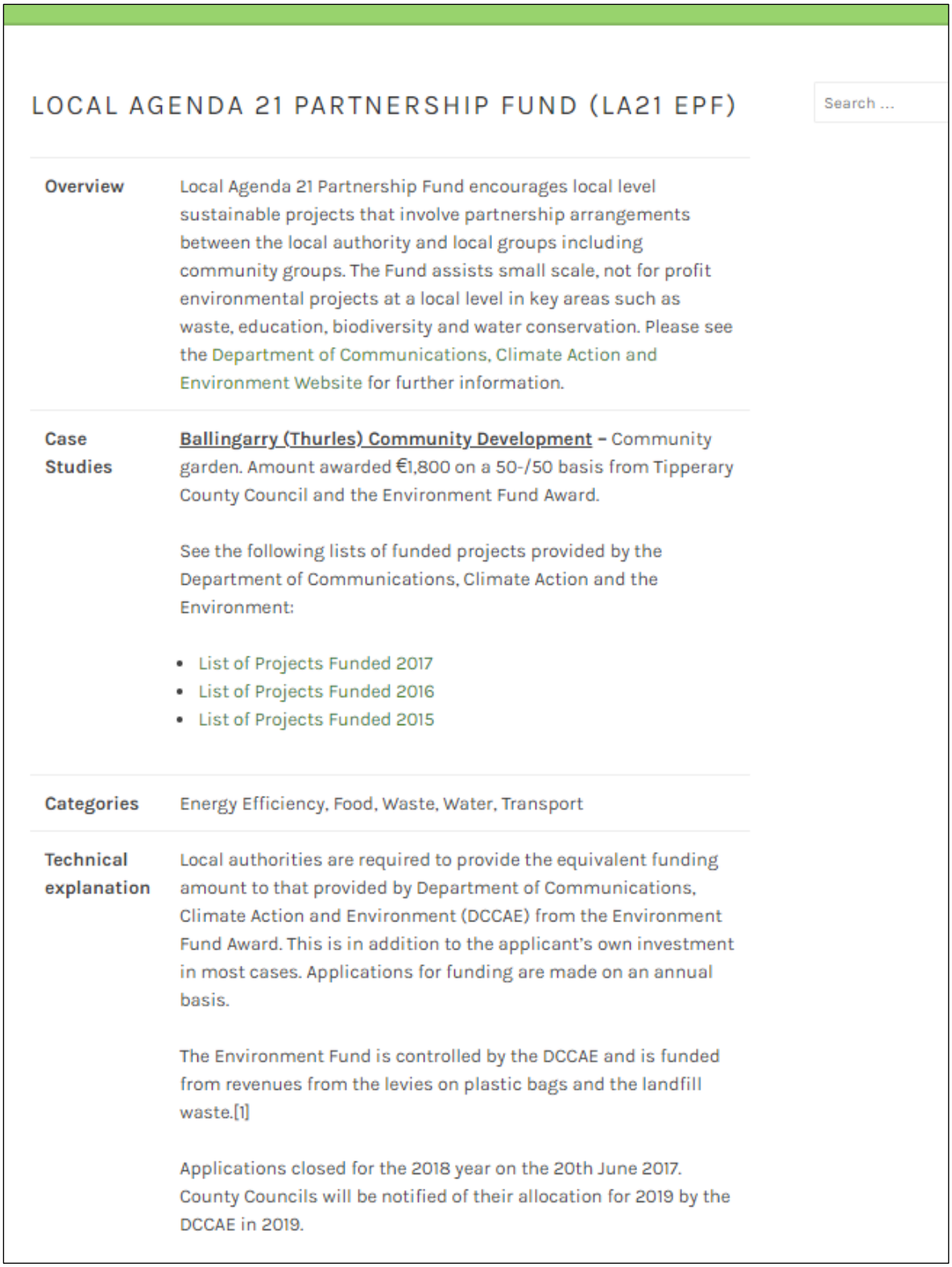
Our project ideas are all about going back to our roots.

1. Allotments – A plot of land rented by an individual for growing food or flowers. For further information on setting up an allotment see Allotments.ie.
2. Community Gardens – The land area is generally larger than an allotment where members of the community can work together and share the duties. The land is not rented but rather an unused area donated by the landowner. For further information see Community Gardens Ireland and Green Side Up. For a list of Dublin based community gardens see Dublin Community Growers.
3. Community Supported Agriculture – A partnership between a group of people and a farmer. Members pay an agreed fee to the farmer and in return get healthy local produced food. For further information see Community Supported Agriculture

Figure 17: Screenshot of community project destination page 'Food'.

4.1.2.5 ‘Funding Sources’

The research team’s environmental consultants identified 24 funding sources which were valuable to local communities (McGarrity and O'Toole 2019). To promote ease of navigation, funding sources were segregated based on community projects. Users were guided to funding sources relevant to their specific goals and actions. ‘Funding Sources’ were accessible from the ‘Get Your Community Group Started’ webpage and the community project theme webpages. They also appeared as a tertiary menu from the navigation bar underneath community projects. Incorporation of multiple access routes was imperative to promoting functionality as information was easier to locate. Financial information was text heavy, therefore in order to reduce information overload, content was broken up into several sections (Chen 2018). These included; Overview, Categories, Case Studies, Technical Explanation and Contact and Website Details. The layout remained consistent for each funding source to promote the development of usage patterns through familiarity. Figure 18 presents the ‘Local Agenda 21’ destination page.



LOCAL AGENDA 21 PARTNERSHIP FUND (LA21 EPF)

Search ...

Overview	Local Agenda 21 Partnership Fund encourages local level sustainable projects that involve partnership arrangements between the local authority and local groups including community groups. The Fund assists small scale, not for profit environmental projects at a local level in key areas such as waste, education, biodiversity and water conservation. Please see the Department of Communications, Climate Action and Environment Website for further information.
Case Studies	**Ballingarry (Thurles) Community Development** – Community garden. Amount awarded €1,800 on a 50-/50 basis from Tipperary County Council and the Environment Fund Award. See the following lists of funded projects provided by the Department of Communications, Climate Action and the Environment: • List of Projects Funded 2017 • List of Projects Funded 2016 • List of Projects Funded 2015
Categories	Energy Efficiency, Food, Waste, Water, Transport
Technical explanation	Local authorities are required to provide the equivalent funding amount to that provided by Department of Communications, Climate Action and Environment (DCCAE) from the Environment Fund Award. This is in addition to the applicant's own investment in most cases. Applications for funding are made on an annual basis. The Environment Fund is controlled by the DCCAE and is funded from revenues from the levies on plastic bags and the landfill waste.[1] Applications closed for the 2018 year on the 20th June 2017. County Councils will be notified of their allocation for 2019 by the DCCAE in 2019.

Figure 18: Screenshot of funding source destination page 'Local Agenda 21'.

4.1.2.6 'Planning Permission'

The legal professional provided information on how to determine if a community project needs planning permission, steps to obtaining planning permission and a list of exempted developments (Hanratty 2019a). These topics made up the three destination pages for 'Planning Permission'. Figure 19 shows an example of layout using 'Does Your Community Project Need Planning Permission?' as the example.

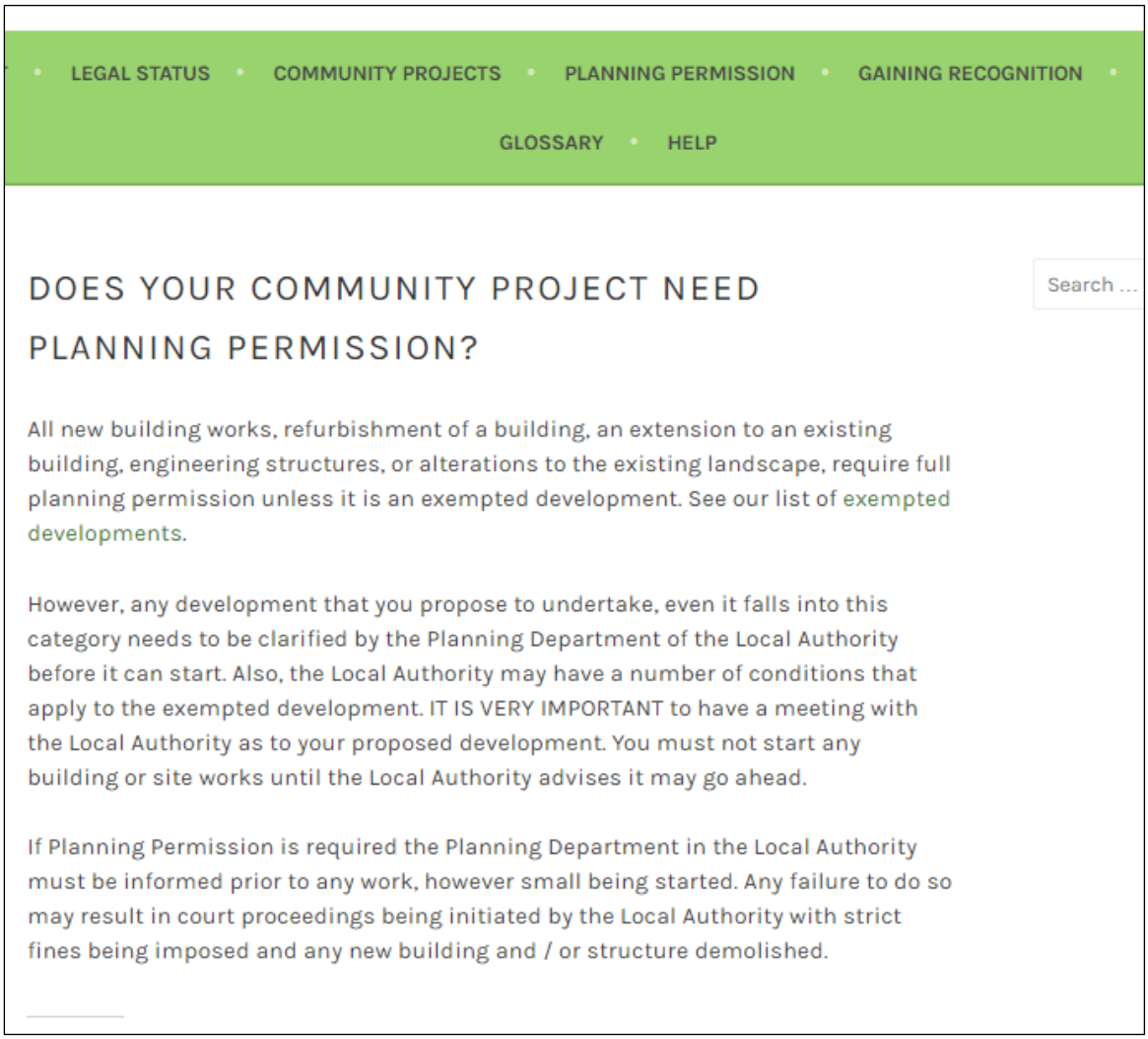


Figure 19: Screenshot of planning permission destination page 'Does Your Community Project Need Planning Permission?'.

4.1.2.7 'Gaining Recognition'

'Gaining Recognition' was aimed at advanced users with experience in community led actions. Content was sectioned into 'Using Management Systems as a Voluntary Community Group' and 'Measuring Progress'. The research team gathered information on management systems applicable to voluntary community groups including, BS 8904:2011 Guidance for Community Sustainable Development, ISO 37101 Sustainable Development

in Communities – Management system for sustainable development, ISO 14000 Environmental Management Systems, ISO 50001 – Energy Management Systems, Eco Management and Audit Scheme, Covenant of Mayors, European Energy Award and Climate Alliance. Measuring progress consisted of two frameworks for measuring and reporting Greenhouse gas (GHG) emissions and one measuring tool. A summary of each was provided along with links to external sources for further information. Figure 20 presents a screenshot of the 'Using Management Systems as a Voluntary Community Group' pathway page within the 'Gaining Recognition' category.

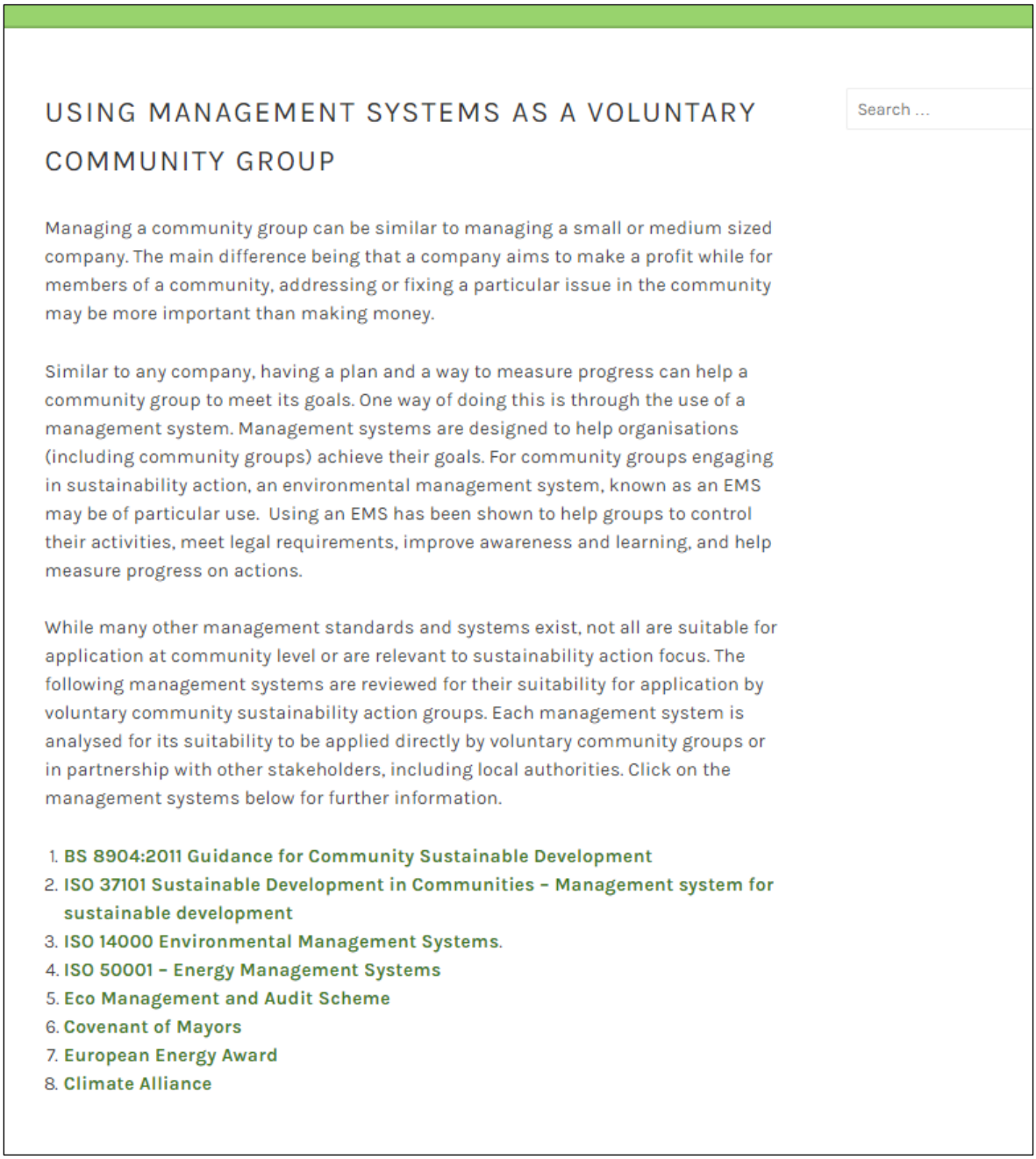


Figure 20: Screenshot of Gaining Recognition pathway page 'Using Management Systems as a Voluntary Community'.

4.1.2.8 'Useful Resources'

A summary of the links provided within the website were included in a separate section named 'Useful Resources'. These were direct links to external sources of information. Figure 21 displays a screenshot of the 'Useful Resources' webpage.

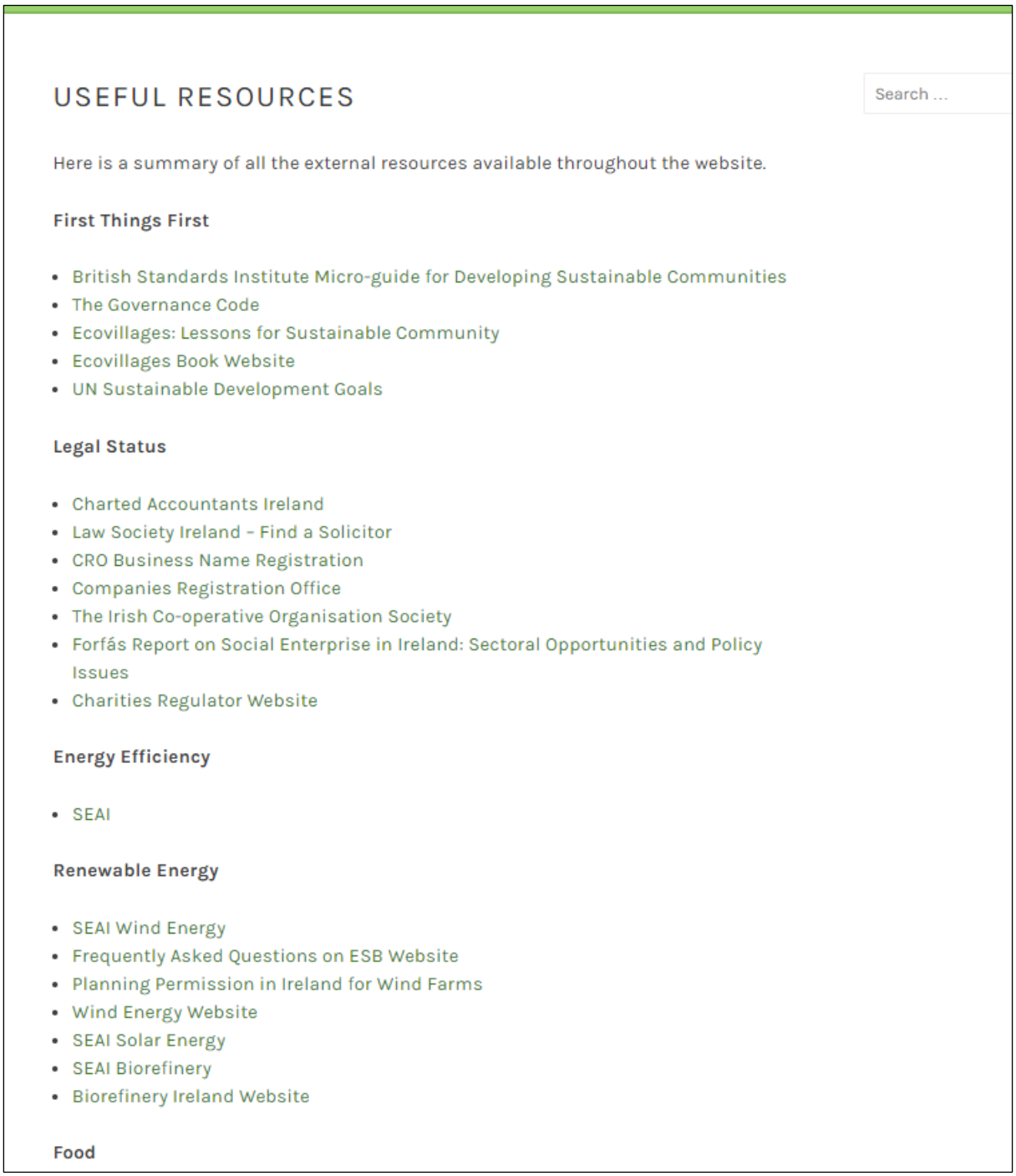


Figure 21: Screenshot of 'Useful Resources' webpage.

4.1.2.9 ‘Glossary’

‘Glossary’ consisted of a glossary defining terminology used in the website and a section on Frequently Asked Questions. Inclusion of these two sections were vital to ensuring all levels of understanding were catered for. The terminology was interactive within the website content, therefore if users were unsure of the meaning of a word they could simply click on the text and be brought to the ‘Glossary’. Figure 22 presents a screenshot of the ‘Glossary’.

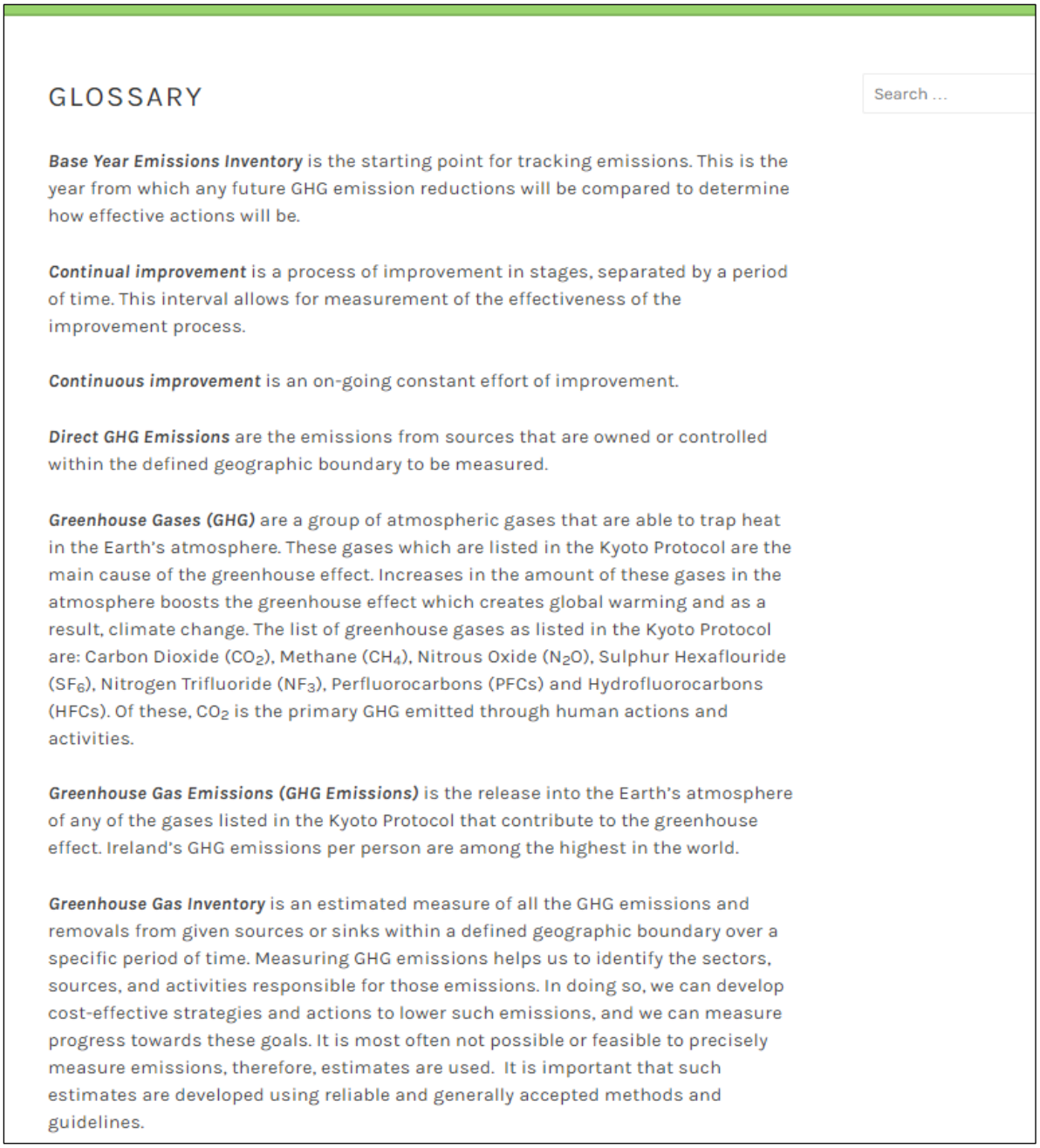


Figure 22: Screenshot of ‘Glossary’ webpage.

4.1.2.10 'Help'

Inclusion of a 'Help' section was a critical element in supporting usability and ease of navigation. The 'Help' section was a manual on how to use the web based DSA. Figure 23 displays a screenshot of the 'Help' webpage describing it as 'How to Navigate the Website'.

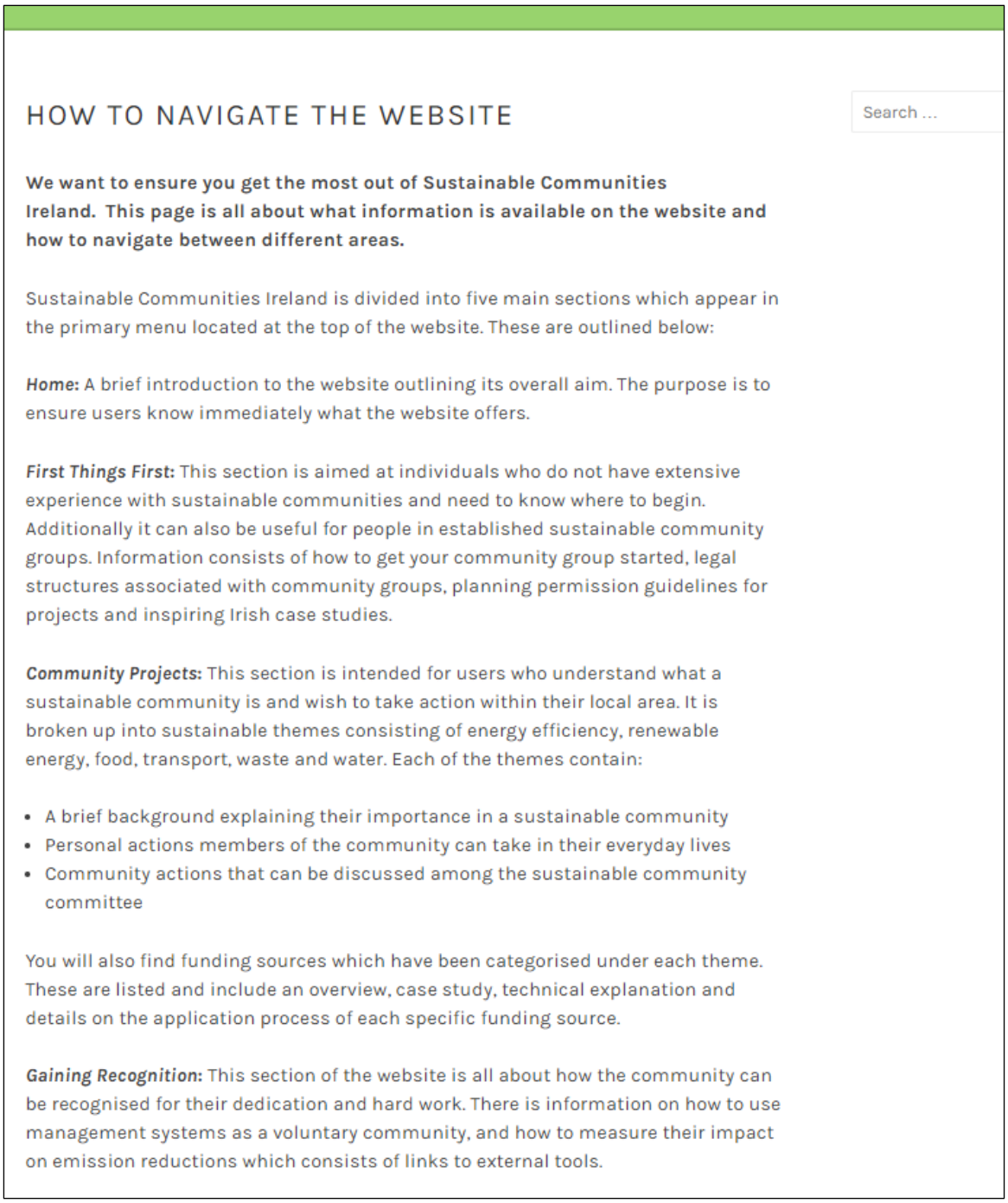


Figure 23: Screenshot of 'How to Navigate the Website' webpage.

4.2 Evaluation of Prototype

Evaluation results were obtained from community groups and the Steering Committee which consisted of members from the EPA and An Taisce. Previous studies carried out in the same field of evaluation and assessment of websites, provided a basis for the assessment framework (Darejeh and Singh 2013; Garett *et al.* 2016). It was important to evaluate the website for usability, accessibility, functionality and practicality. Therefore, evaluation focused on ease of navigation, usefulness of content, language used and accessibility. Results have been presented in separate sections to exemplify individual feedback.

4.2.1 Community Evaluation Results

An evaluation form was sent to two community groups accompanied by a link to the website. Each community group was given a month to assess the website and return the completed evaluation form. Table 9 details the questions asked.

Question	Optional Answers	Type of Question
In your opinion does this information tool:	• Encourage community groups to take action. • Provide practical information on finance and legal issues. • Provide inspiration for newer community groups to take action through the case studies provided. • Provide inspiration for experienced community groups to take more ambitious action. • Other, please explain.	Closed ended question.
How easy is it to find information on the website?	• Scale of 1 to 5 with 1 being difficult 5 being easy.	Rating question.
How useful is this information to a voluntary community?	• Scale of 1 to 5 with 1 being difficult 5 being easy.	Rating question.
Is the language used clear and easy to understand?	• Scale of 1 to 5 with 1 being difficult 5 being easy.	Rating question.
In what way could the information provided be improved?	• Comment box.	Open ended question.
Any other comments?	• Comment box.	Open ended question.

Table 9: Questions from evaluation form given to community groups.

There was a consensus among reviewers, that the website was an effective and useful tool with potential to aid implementation of sustainable community initiatives at the local level. Each community group agreed with the following statements:

- Encourage community groups to take action;
- Provides practical information on finance and legal issues;
- Provides inspiration for newer community groups to take action through case studies;
- Provides inspiration for experienced community groups to take more ambitious action.

Additional comments included:

- Sources of finance section excellent;
- Case studies give a practical aid to understanding potential actions;
- Fantastic resource for both new and existing community groups in learning about what's possible, how to start and how to take further action.

However, there were further comments in relation to 'ambiguous' language, particularly on the Homepage. Consequently, further work was conducted to ensure the language was more user friendly. Overall the feedback was positive regarding accessibility, relevance of content and website navigation. Additionally, one of the community groups suggested the expansion of content to include employment opportunities, training opportunities, public relations training, use of social media and conflict resolution. The evaluation findings were extremely useful in identifying practicality and effectiveness of content, in addition to highlighting the necessity to reformat and rephrase parts of the language used to enhance usability.

4.2.2 Steering Committee Evaluation Results

Assessment of the web based DSA by the Steering Committee was carried out through a live demonstration. As detailed in Section 3.1.4.2, the Steering Committee consisted of two EPA members and one from An Taisce. Each member contributed unique expertise from their associated backgrounds in sustainable urban town planning, environment and health and sustainable transport. Members of the committee were asked about appearance, functionality, navigation, scope of content and usability. Results were retrieved by means of an open discussion. Table 10 presents the Steering Committee feedback.

Category	Feedback
Appearance	Web based DSA resembles basic information sheets with all webpages reflecting similar layouts therefore need more variety between sections.
Functionality	Webpages provide relevant content, but little interaction therefore needs interactive material to engage users.
Navigation	Easy to navigate however needs further planning to emphasise decision support element. General categorisation of content was okay.
Scope of Content	Need to broaden scope of content to include more links to external resources, list of existing sustainable community groups, link to 'The Wheel' guidance documents, a greater emphasis on benefits of sustainable communities to encourage engagement and expansion of community projects beyond energy.
Usability	Language used needs to be more approachable and user friendly especially in relation to the Homepage, First Things First, Food, Transport and Gaining Recognition sections.

Table 10: Steering committee evaluation feedback from demonstration of prototype.

Overall the Steering Committee were satisfied with the content in relation to practicality stating, 'It is comprehensive in its content, and reflects what has clearly been a lot of effort.' However, they felt navigation could be enhanced to emphasis the decision support element, 'It needs further planning and creativity though to bring it to the next level of being really about guiding decisions and/or offering some kind of logical/contiguous journey'. Additionally, they suggested usability could be improved on certain webpages by rephrasing language used to stress a more user-friendly engaging tone, and greater incorporation of short paragraphs and bullet points. The scope of content also required expansion including additional links to external sources, a list of existing sustainable community groups and a new community project theme to reduce the focus on energy. The evaluation was extremely productive in influencing establishment of the finalised web based DSA.

4.3 Modifications

Modifications were carried out based on evaluation feedback from the community groups and Steering Committee. Further training was acquired in WordPress.org website development and user-experience design in order to accommodate a redesign of the prototype. Table 11 presents a summary of resulting modifications formulated to address concerns raised in the evaluation process.

Category	**Community Group Feedback**	**Resulting Modifications**
Usability	Ambiguous language, grammatical errors and miss spellings.	Revised wording of Homepage and introduction pages and rectified errors.
Scope of Content	Very useful content.	Existing content remained unchanged.
Category	**Steering Committee Feedback**	**Resulting Modifications**
Appearance	Basic appearance with little emphasis on decision support.	Redesign of DSA to incorporate more imagery, colours and varied presentation of content. Restructuring to include four distinct decision stages.
Functionality	Simple layout with minor interactive elements.	Incorporation of interactive lists, decision trees, decision guides and factsheets.
Navigation	Straight forward but needs greater incorporation of decision support.	Created a new category titled 'Decisions….Decisions….', which was made up of four decision stages that presented the primary legal and financial content.
Scope of Content	Inadequate number of links to external sources of information.	Additional links integrated where suitable.
	Too focused on energy as a community project.	Biodiversity added to list of community projects.
	Greater emphasis needed on benefits of sustainable communities.	Included list of benefits associated with getting involved.

Usability	'First Things First' written in technical manner and not engaging enough.	Rewrote content for 'First Things First' to instead include 'About Us' and 'What is a Sustainable Community and Why Should You Care?'.
	Homepage underdeveloped and does not mention decision support or guidance enough.	Redesigned Homepage and rewrote welcome paragraph.
	'Get started with Your Community Group' section was too technical.	Created a list of steps needed to form a sustainable community instead.
	Language too technical for Food, Transport and Gaining Recognition.	Reviewed terminology used.

Table 11: Summary of modifications carried out on web based DSA resulting from evaluation feedback.

Building the finalised version on WordPress.org allowed for greater functionality to achieve the scale of redesign necessary in addressing evaluation feedback. Re-categorisation of content and amendment of navigation was undertaken to create a new layout with revised content.

4.4 Discussion of Modifications and Redesign

The following sections discuss the full extent of modifications carried out relevant to each category addressed in the evaluation process. Table 11 summarises the modifications carried out. Through these modifications the web based DSA took on a whole new appearance. The redesign is depicted using image screenshots from the finalised WordPress.org version. The finalised version was called www.sustainablecommunities.ie as discussed in Section 3.1.2.2.

4.4.1 Appearance

Feedback indicated appearance of the web based DSA was basic and lacked diversity. Furthermore, there was not enough emphasis on the decision support element. Therefore, the entire web based DSA was redesigned to create a more approachable, and engaging

look and feel. For appearance purposes the Homepage and ‘First Things First’ have been detailed below using screenshots to represent the new design.

4.4.1.1 Homepage

Evaluation feedback suggested that the Homepage was too technical and not representative of a decision support website. Therefore, the entire Homepage was redesigned to encapsulate a more professional appearance, with clear indication of decision support content. Figure 24 presents the improved Homepage for the finalised version. Information was shortened and interactive buttons were included to diversify representation of content and encourage engagement. The primary content was accessible directly from the interactive boxes and navigation menu, therefore encouraging easy access through multiple routes of retrieving information (Redish 2012). This also allowed users to scan the primary content quickly, which is a crucial mechanism for presenting information on the web (Dick 2017). The navigation menu remained at the top of the website as it was acknowledged to be the most beneficial positioning (Murano and Lomas 2015). Green was used as a recurring colour throughout for interactive links and navigation to subtly highlight the environmental aspect of the web based DSA. The overall appearance was enhanced using imagery and colour which was absent in the prototype.

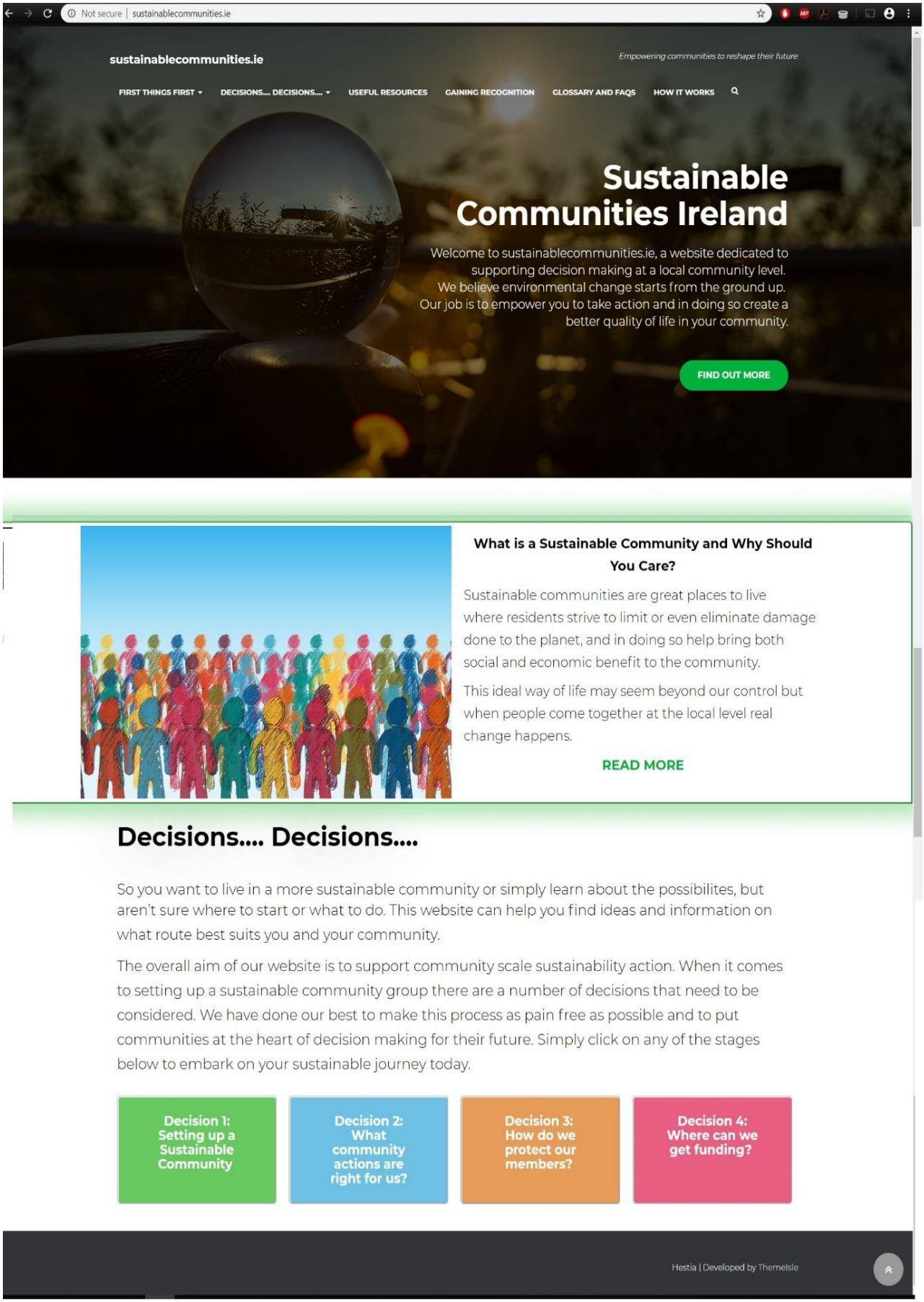


Figure 24: Screenshot of sustainablecommunities.ie Homepage.

4.4.1.2 'First Things First'

'First Things First' was reviewed to reduce technical terminology and further improve the conversational, positive tone of writing by incorporation of 'we' and 'you' in text (Redish 2012). In doing so the original 'Get Your Community Group Started' web page was discarded and replaced with 'About Us' and 'What is a Sustainable Community and Why Should You Care?'. 'About Us' delivered information on the purpose of the web based DSA and who it was aimed at. This section was made accessible through the 'Find Out More' interactive button, located below the welcome message on the Homepage, therefore prompting users to start here and gain an understanding of what the website had to offer. 'What is a Sustainable Community and Why Should You Care?' was designed to encourage greater awareness raising. This was a fundamental concern addressed at the EPA meeting. It was crucial to explain the importance of getting involved at the local level to inspire motivation and action. Content comprised a short summary of the negative implications of climate change, a basic definition of sustainable communities and a list of benefits associated with setting up sustainable communities. Use of imagery was utilised to break up text heavy content and structure the overall web page appearance. Figures 25 and 26 present screenshots of the 'About Us' destination page and 'What is a Sustainable Community and Why Should you Care?' destination page, highlighting the use of short paragraphs and imagery to enhance readability. It is important to note all web pages were redesigned in a similar manner to the Homepage and 'First Things First', with the aim of creating a more diverse and intriguing overall appearance. However, maintaining a simplistic layout remained a fundamental aspect of web page design as to avoid visual complexity (Chen 2018). Therefore, it was essential to attain the correct balance by incorporation of active and passive white space (Redish 2012). As a result of these modifications a distinguished, professional, yet simplistic appearance was achieved.

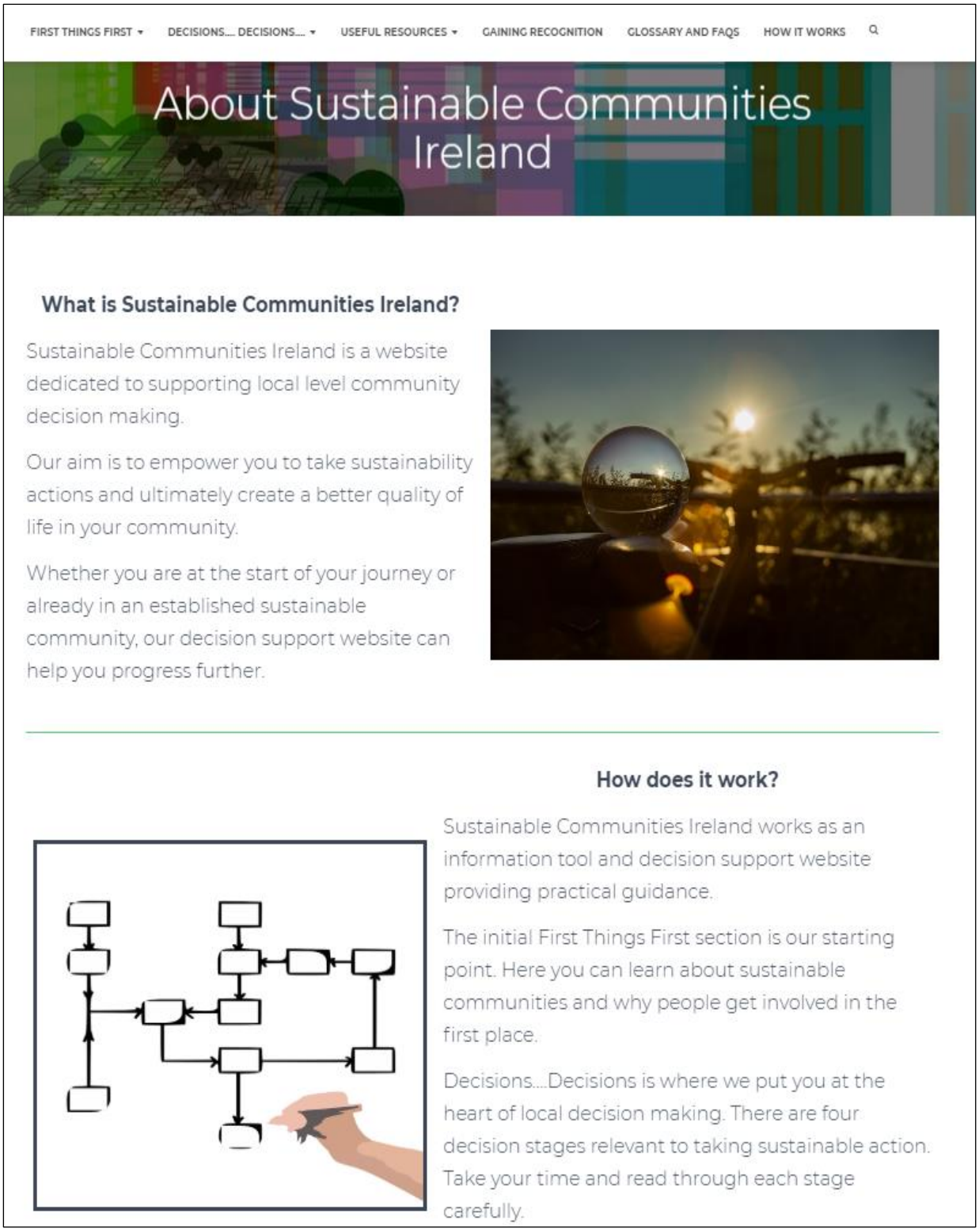


Figure 25: Screenshot of 'About Us' destination page.

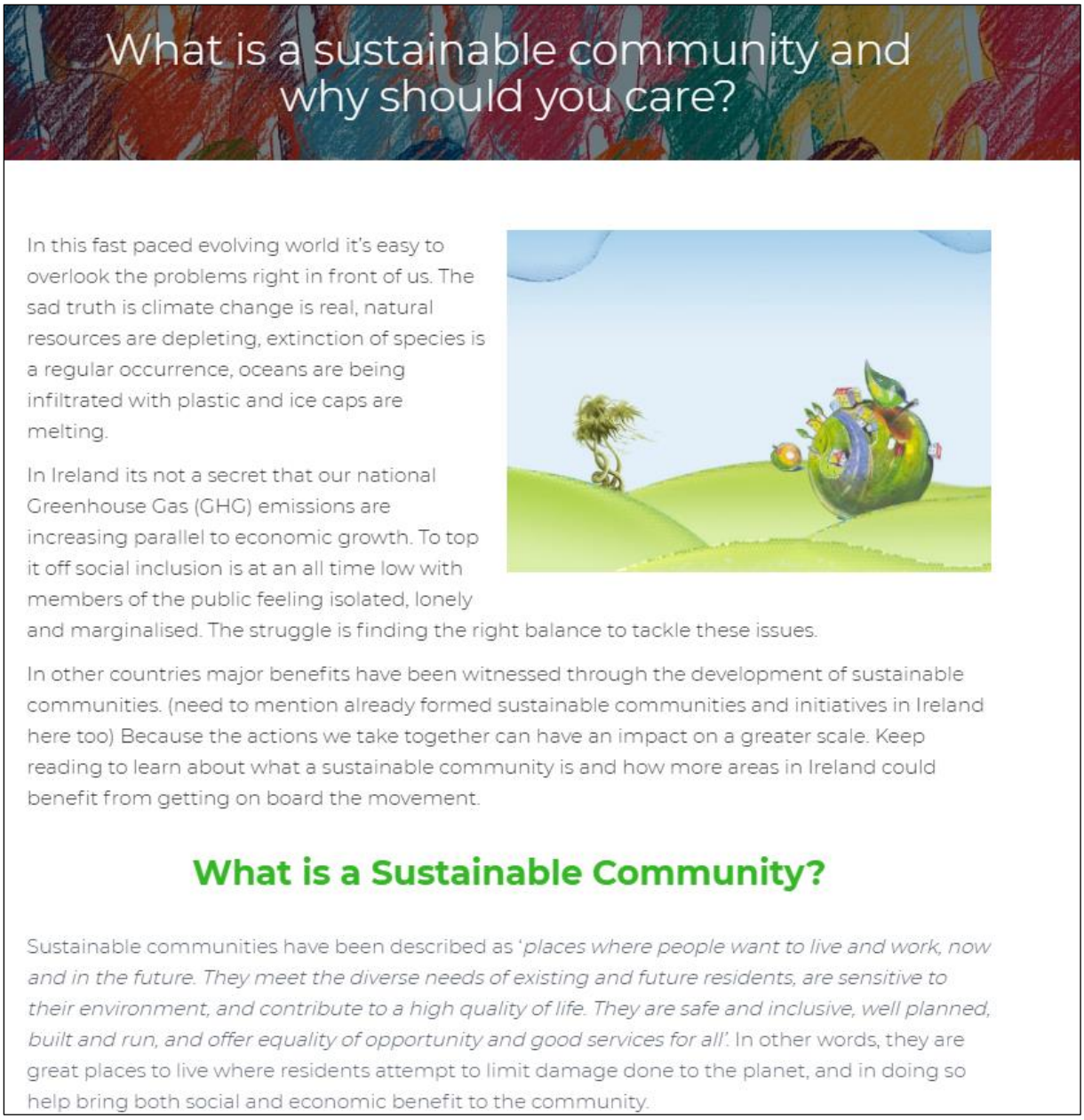


Figure 26: Screenshot of 'What is a Sustainable Community and Why Should You Care?' destination page.

4.4.2 Functionality and Decision Support

The original sections titled 'Get Your Community Group Started', 'Community Projects', 'Legal Status' and 'Funding Sources', as detailed in Section 4.1.2, were re-categorised into four prominent decision stages focused on the end goal of establishing a sustainable community. The decision stages were numbered one to four and named 'Setting up a Sustainable Community', 'What Community Actions are Right for Us?', 'How Do We Protect Our Members?' and 'Where Can We Get Funding?'. The sequence was chosen to outline a contiguous journey of decision making and address all levels of understanding, from new community groups to established ones. Each decision stage was represented in a

consistent layout with the same destination pages except ‘Setting up a Sustainable Community’. ‘Setting up a Sustainable Community’ was the overall introduction to sustainable communities, therefore destination pages consisted of ‘Steps to a Sustainable Community’, ‘UN SDGs’ and ‘Inspiring Case Studies’. Decision stage 2, 3 and 4 demonstrated a uniform layout with destination pages consisting of a list of interactive steps to get started, a decision tree, a decision guide and fact sheets. Content was delivered in a variety of methods to enhance interaction and extend functionality. The decision stages were made accessible from multiple routes on the website including the Homepage, navigation menu and ‘How It Works’ webpage. The overall category was titled ‘Decisions….Decisions….’ which appeared on the primary navigation menu with the decision stages represented as the secondary drop-down menu. Figure 27 presents the sitemap for the navigation process. The colours are representative of the content and mirror the colours used in the web based DSA.

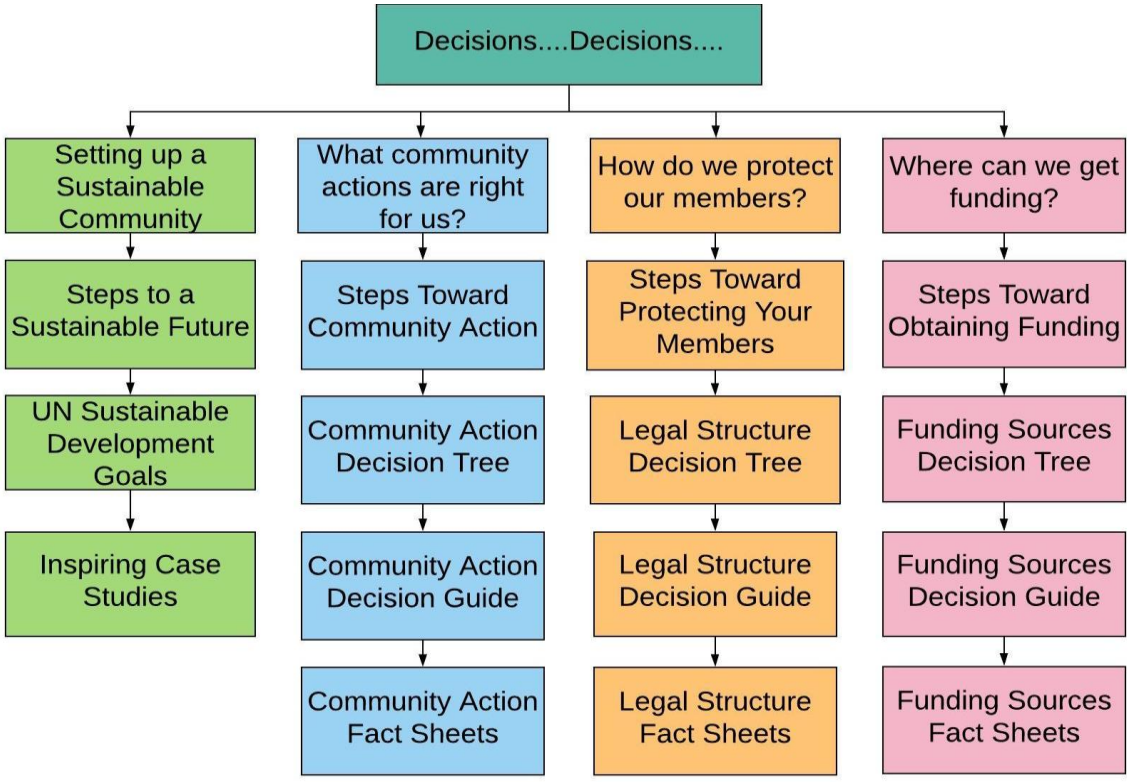


Figure 27: Sitemap indicating primary and secondary menu navigation of ‘Decisions….Decisions….’.

The following sections demonstrate the enhancement of decision support material within the destination pages using ‘Decision Stage 2: What community actions are right for us?’ as an example. Figure 28 indicates the general layout of each decision stage pathway page, highlighting the use of interactive boxes and an animated progression bar to diversify

appearance and enhance user interaction. The progression bar indicates to users what phase of the decision stage journey they are in.

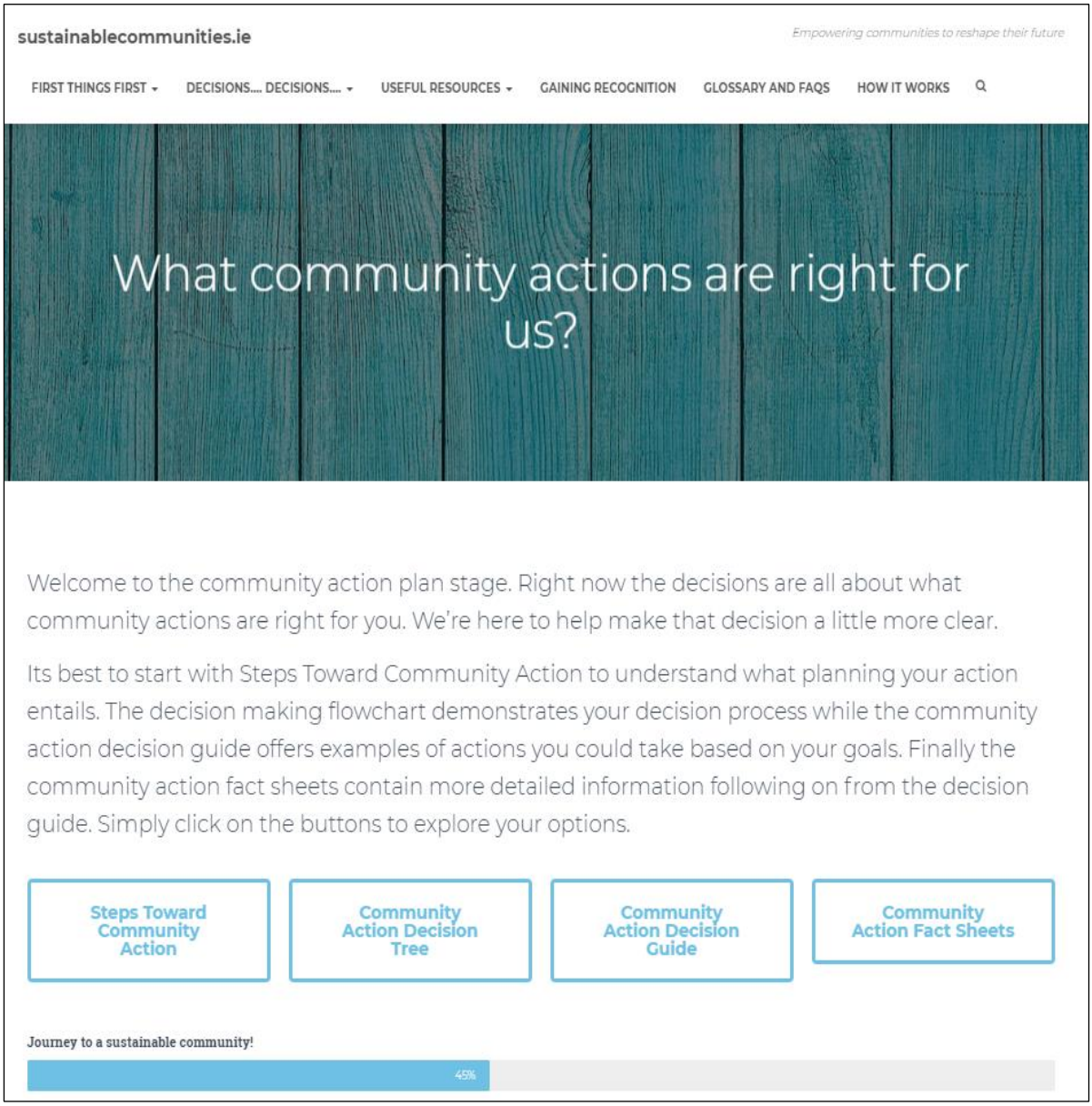


Figure 28: Screenshot of 'Decision Stage 2: 'What community actions are right for us?' pathway page.

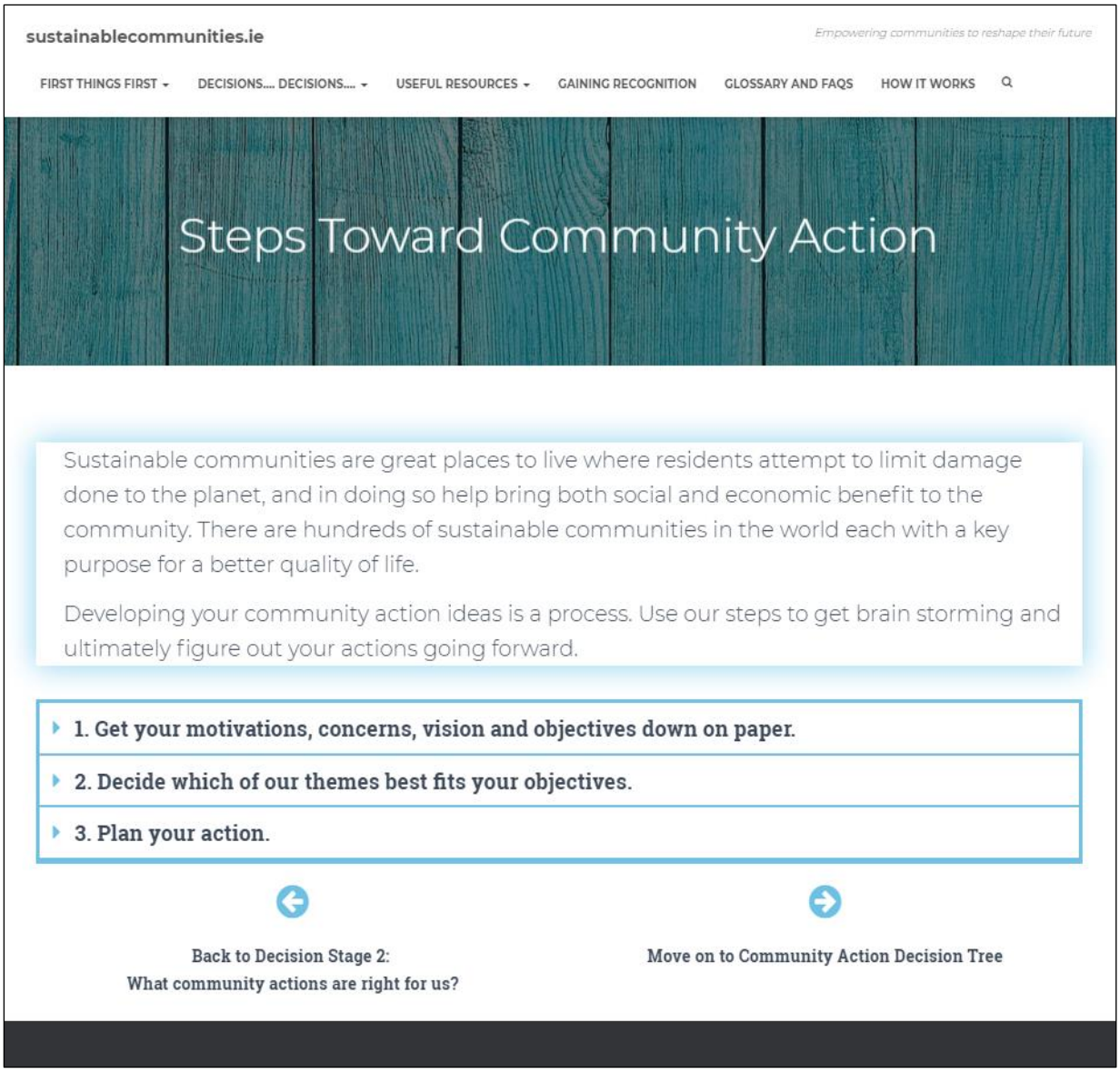


Figure 29: Screenshot of 'Steps Toward Community Action' destination page.

'Steps Toward Community Action' was introduced with a brief description of the importance of sustainable communities, followed by an interactive list of steps necessary in carrying out community action as shown in Figure 29. Users are prompted to continue to the decision tree and decision guide within the list of steps, and at the bottom of the page using navigation arrows.

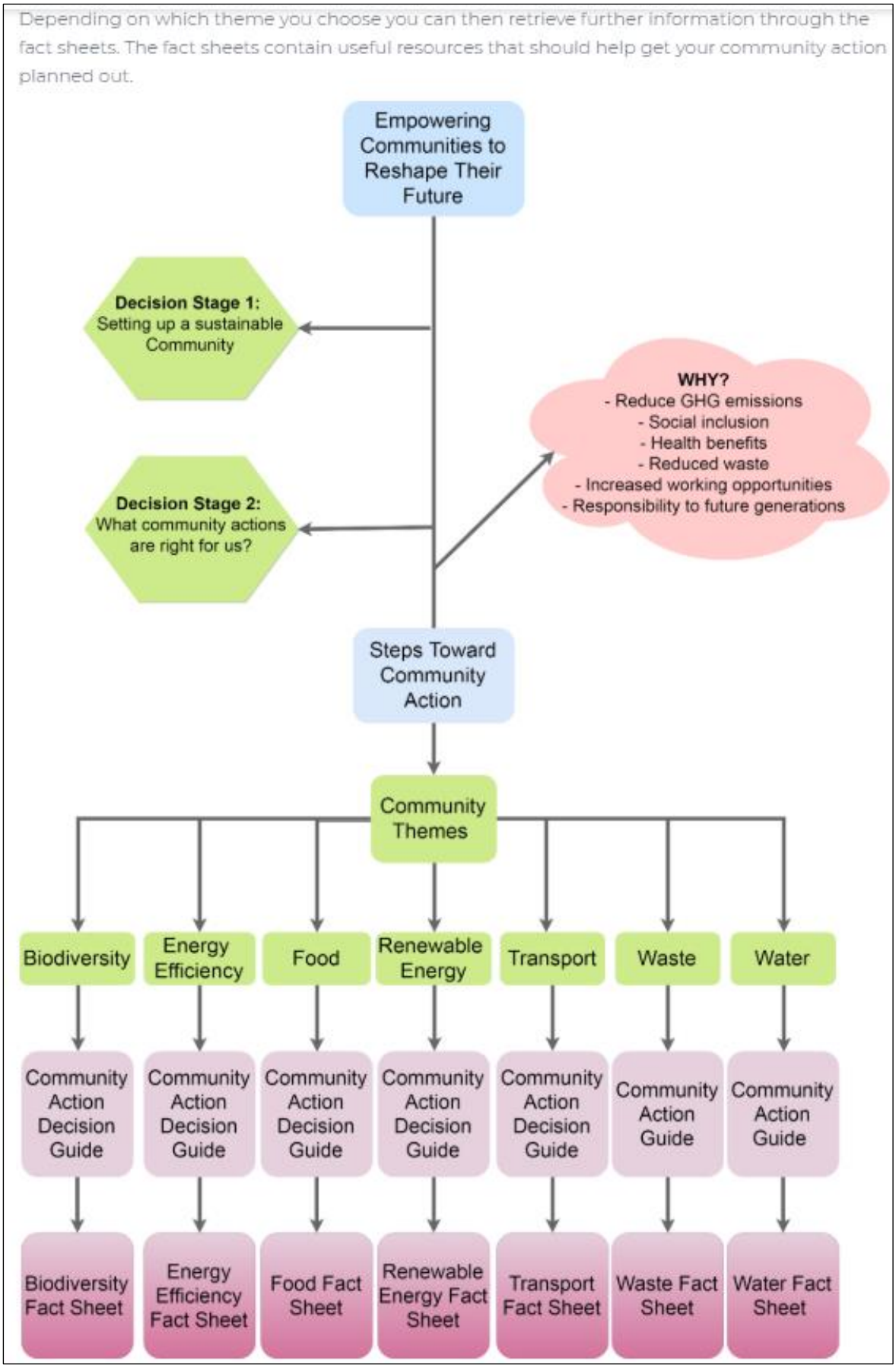


Figure 30: Screenshot of 'Community Action Decision Tree'.

The decision tree presents a layout of decision navigation. It highlights the possible routes a user could take to retrieve useful information relevant to their community goals. Green indicates the decision stages, while pink specifies the information pages with level of detailed content represented by the intensity of colour. As observed in Figure 30, the original hierarchy web layout used in the prototype version endured as it was the most efficient method for presenting content rich information.

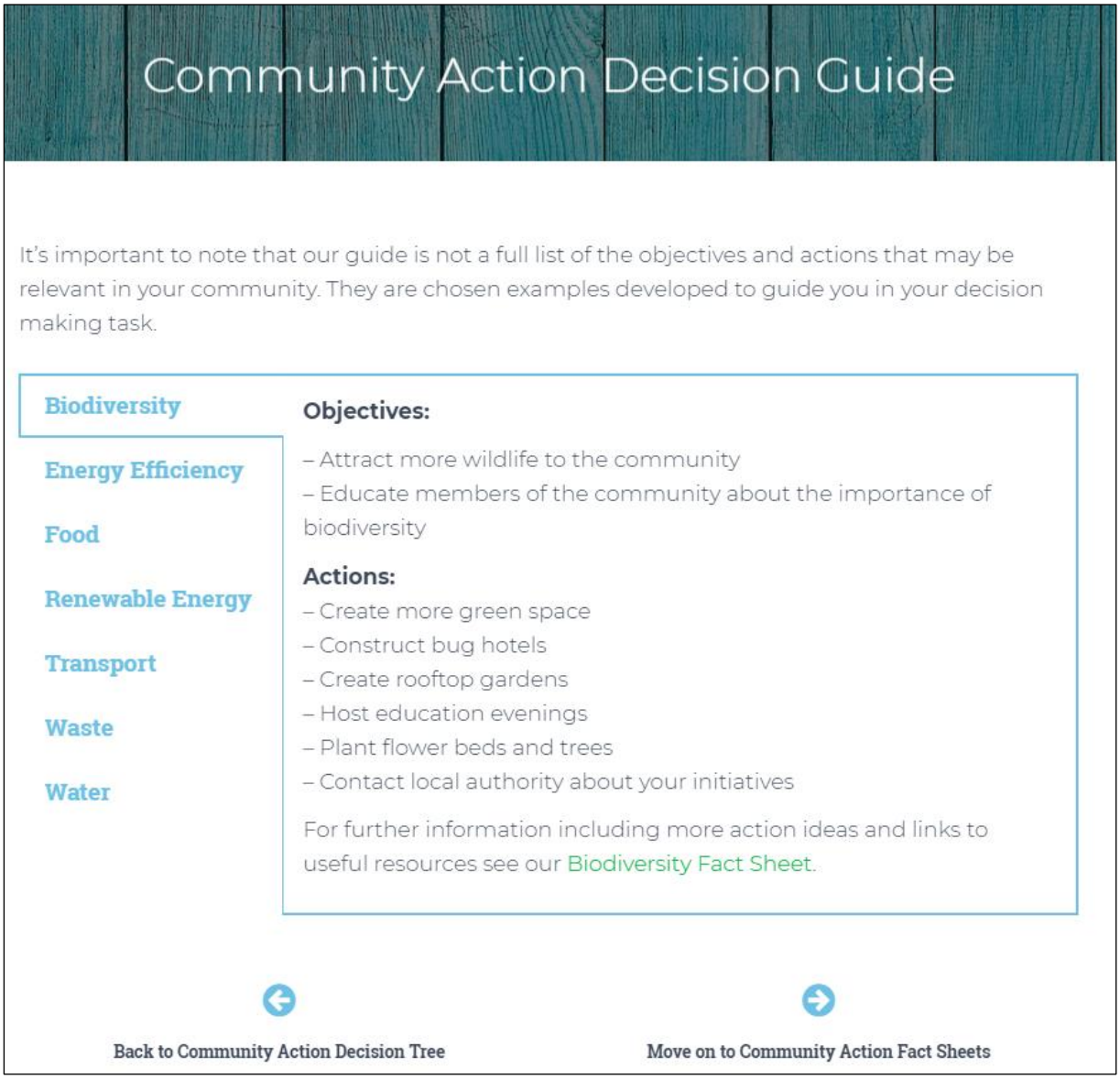


Figure 31: Screenshot of 'Community Action Decision Guide' pathway page.

Abiding by the hierarchy web layout, the decision guide depicts examples of community actions based on common community objectives, in a brief and summarised format to provide users with basic information initially. This is essential to empowering users in making an informed decision. By presenting information in a waterfall format, information

complexity is reduced. Therefore, the decision guide acts as the pathway page. The decision guide is represented in Figure 31.

Figure 32: Screenshot of 'Community Action Fact Sheets' pathway page.

The Fact Sheets present the full comprehensive content. Figure 32 presents an example of the 'Community Action Fact Sheets' pathway page. In the finalised web based DSA the fact sheets are presented as interactive icons instead of interactive links which were used in the prototype. Evaluation of the prototype revealed that content was identified as practical therefore content remained unchanged on the destination pages. However, expandable links were integrated to break up appearance of text heavy content. This approach was utilised to present the legal and financial information as shown in Figure 33. Instead of displaying compressed content immediately, as was executed in the prototype,

see Section 4.1.2.3, the user is provided with a list of expandable links to aid scannability and discourage information overload.

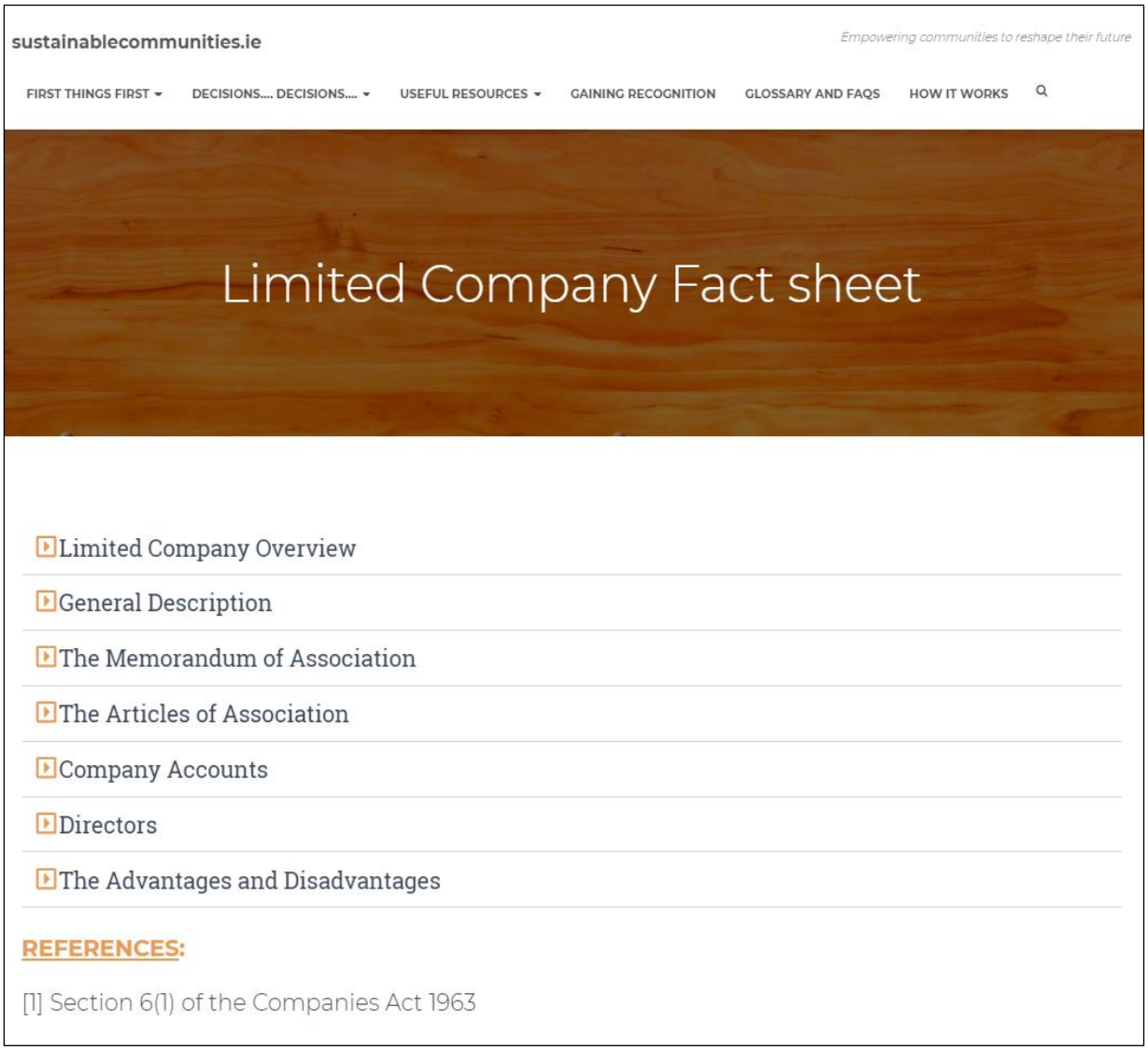


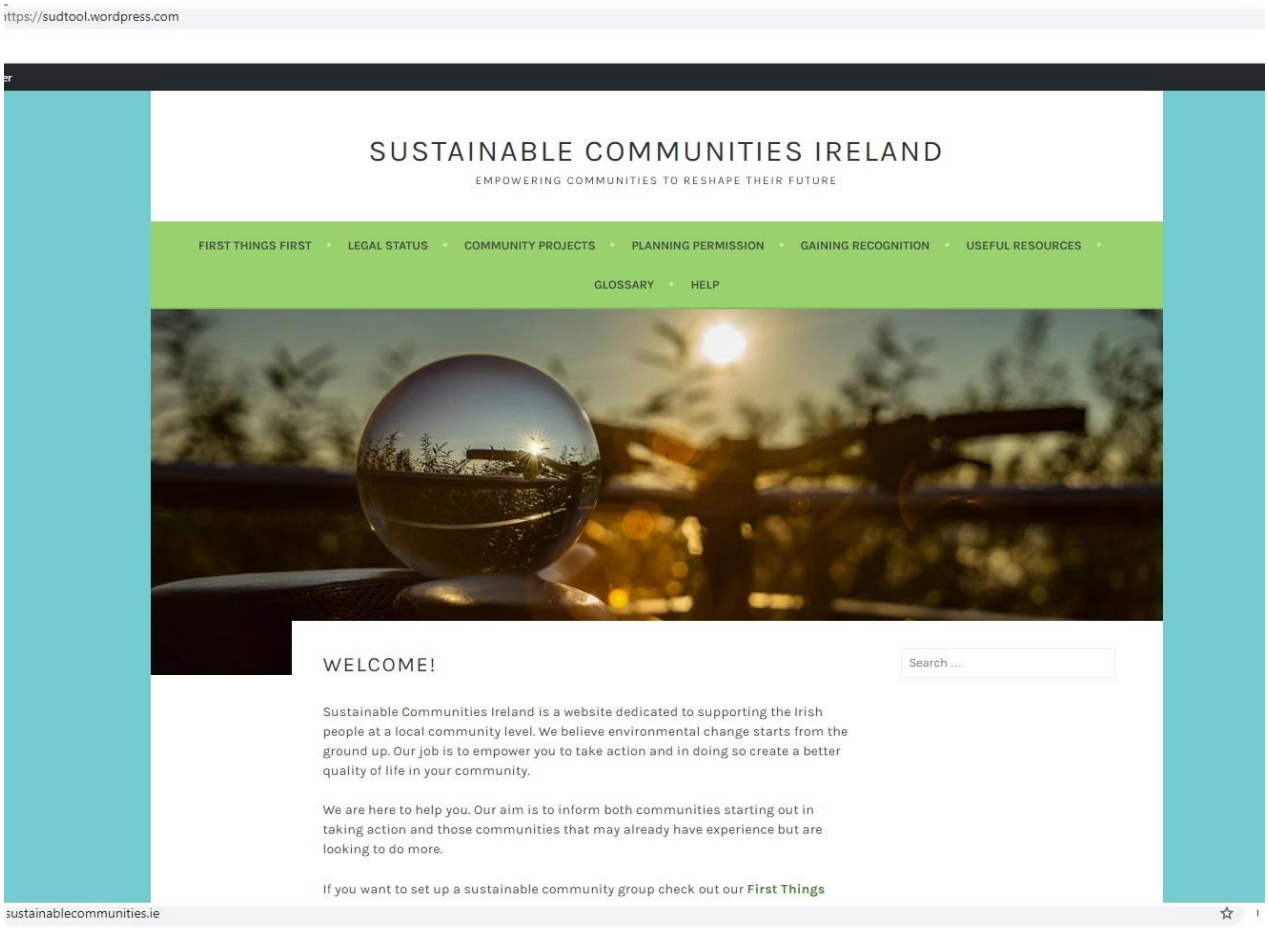
Figure 33: Screenshot of 'Limited Company Fact Sheet' destination page.

Overall the incorporation of interactive material such as buttons, icons and expandable lists, promoted the extension of features beyond uniform information sheets by enhancing functionality and diversity. As a result of these modifications, functionality was significantly improved, and decision support material became the primary focus of the web based DSA.

4.4.3 Navigation

Navigation was described as straight-forward but further planning was needed to emphasise decision support. Therefore, it was important to maintain the simplistic navigation present in the prototype by preserving the horizontal navigation menu with secondary and tertiary

dropdown menus. However, the amount of primary categories were reduced. As detailed in Section 4.1.2, the original primary categories present in the prototype included ‘First Things First’, ‘Legal Status’, ‘Community Projects’, ‘Funding Sources’, ‘Planning Permission’, ‘Gaining Recognition’, ‘Useful Resources’, ‘Glossary’ and ‘Help’. These extended into two lines for the navigation menu which added an unnecessary element of visual complexity. Therefore the categories were reduced to include ‘First Things First’, ‘Decisions….Decisions….’, ‘Useful Resources’, ‘Gaining Recognition’, ‘Glossary and FAQs’ and ‘How it Works’. See Figure 34 for a comparison of the original prototype and the finalised DSA sustainablecommunities.ie. The number of primary categories were reduced by the inclusion of ‘Decisions….Decisions….’. ‘Decisions….Decisions….’ restructured the community projects, legal structures and funding sources thereby reducing the length of navigation menu and emphasising the decision support element of the website. The previous Section 4.4.2, on Functionality and Decision Support, details the incorporation of decision material through integration of this new category. The navigation progression is outlined in Figure 27. To further enhance the navigation process, navigation arrows were added to the bottom of each decision stage page, as to guide users to the succeeding section. This can be seen in Figures 29, 31 and 32. The decision stages were also colour co-ordinated throughout the DSA to assist usability. Furthermore, internal search facilities remained a key feature of each webpage. By using a combination of original techniques and modifications, enhancement of navigation was achieved for the finalised web based DSA.



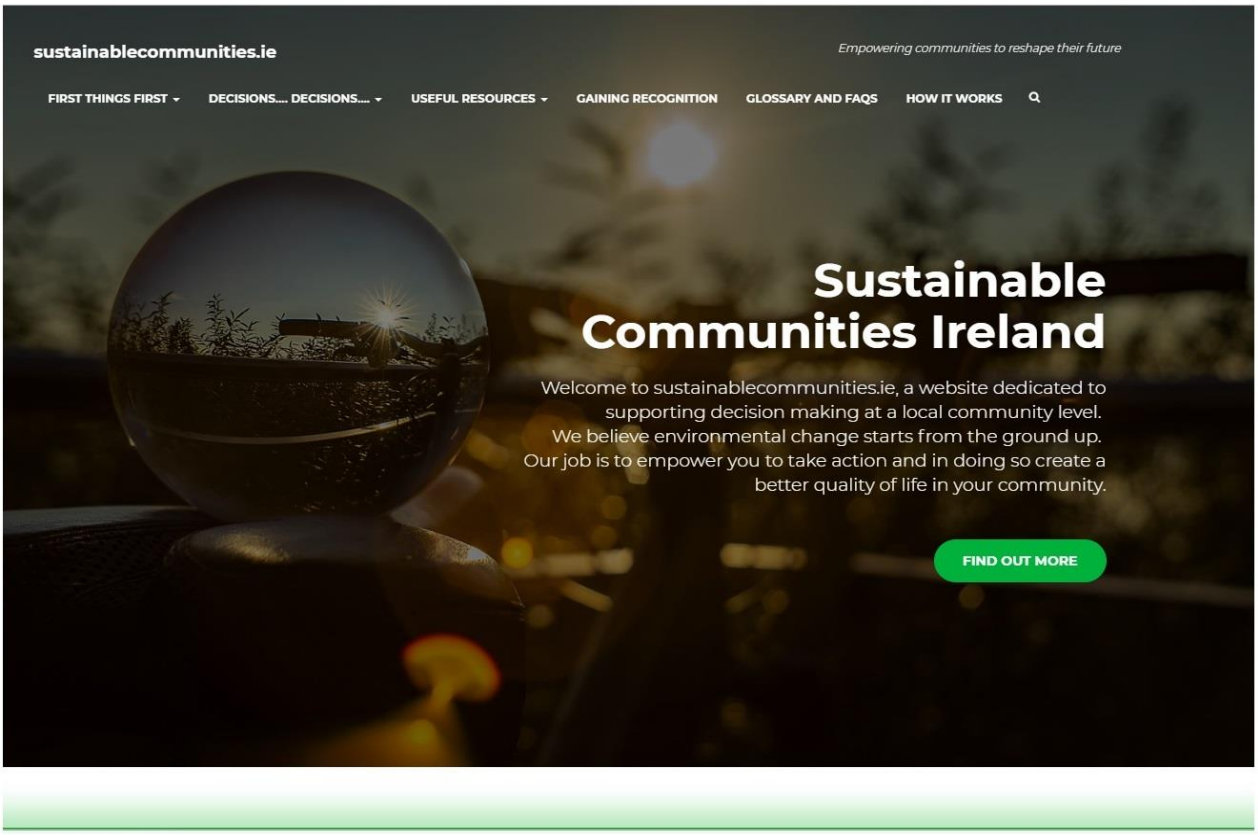


Figure 34: Comparison of navigation on finalised web based DSA, sustainablecommunities.ie and prototype, sudtool.wordpress.com.

4.4.4 Scope of Content

Evaluation feedback recognised limitations within the scope of content. In order to overcome these limitations, the scope of content was expanded. Some recommendations were achievable such as incorporation of an existing list of environmental organisations, broadening of community themes and integration of 'The Wheel' documentation. However, community evaluation suggested inclusion of employment opportunities, training opportunities, public relations training and conflict resolution which were beyond the skills and expertise of this project. Additionally, there are other web based Irish sources, such as 'The Wheel', that provide information on training and organised events (Wheel 2019). Work was carried out to recover a comprehensive list of environmental organisations which were added to the existing useful resources. Additional external links were incorporated into existing content where appropriate, including The Wheel's pdf guidance documents on governance code and sustainable communities. The steering committee exhibited concern over the emphasis on energy within community projects, therefore 'Biodiversity' was integrated as a seventh theme. Biodiversity is an imperative aspect of local sustainability, therefore there existed a wide range of realistic community actions to promote. The primary focus was on encouraging biodiversity in the community by establishing open green space, planting native species, reducing pesticide use, erecting bird boxes and bug hotels, composting, conducting wildlife surveys and educating community members through organised events and talks. Figure 35 depicts the 'Biodiversity Fact Sheet'. The inclusion of biodiversity added a crucial element of ecology which was overlooked in the prototype. Receiving feedback on the scope of content was essential to ensuring a broad range of practical, user relevant content was delivered and all aspects of sustainable development were addressed.

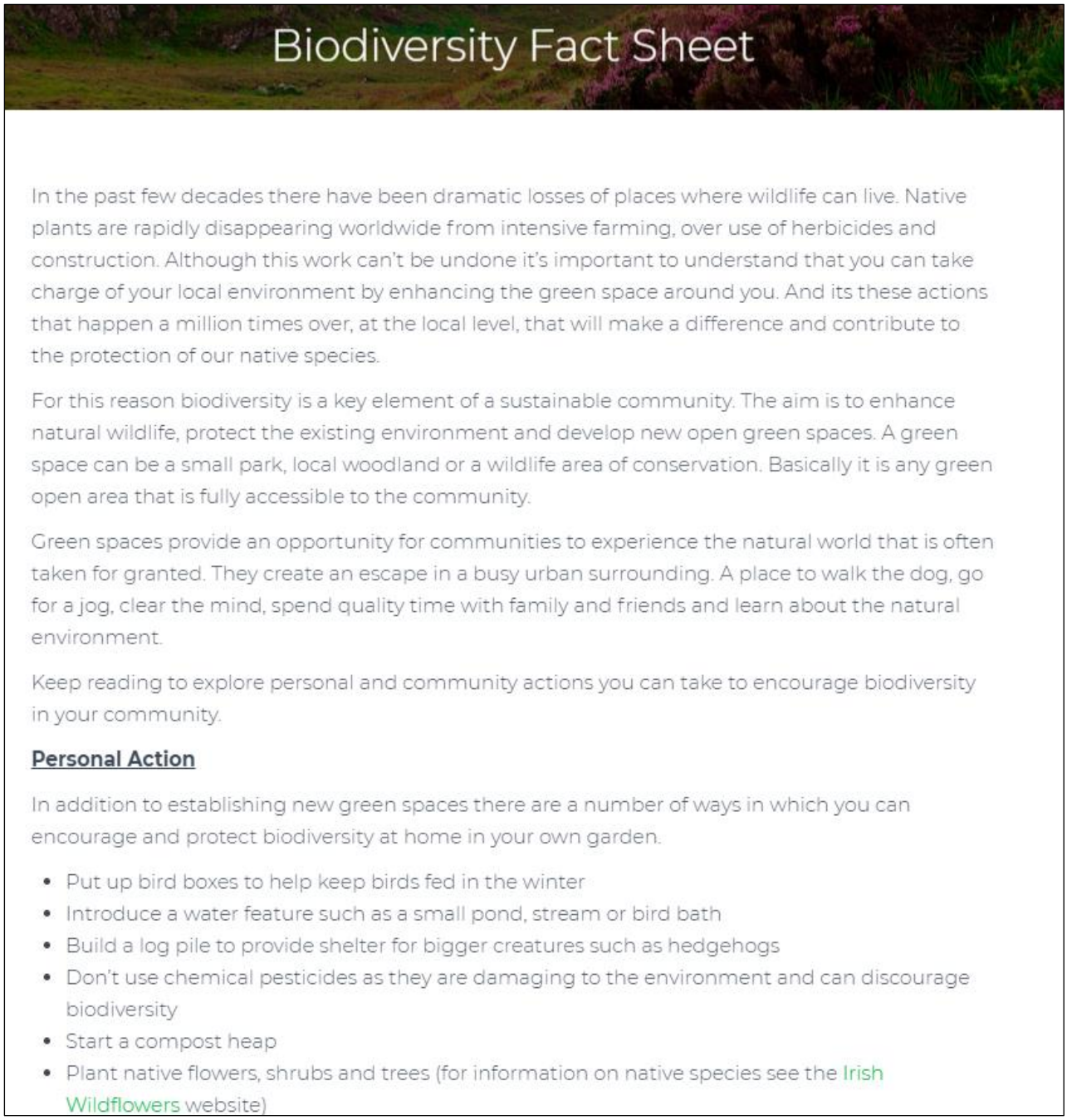


Figure 35: Screenshot of 'Biodiversity' factsheet.

4.4.5 Usability

Efforts made to enhance usability have been discussed in Sections 4.4.1, 4.4.2 and 4.4.3. When modifying the web based DSA, user centred criteria was central to influencing organisation of content, location of imagery, positioning of text and integration of interactive material. Feedback also suggested usability could be improved in relation to written content. Although content was useful, it was also identified as text heavy, and in some cases too technical. Consequently, further research was conducted on user experience design and how to write engaging content for the web (Goldsborough 2012; West 2016).

Content was revised on the ‘Homepage’, ‘About Us’, ‘What is a Sustainable Community and Why Should You Care’, ‘Community Action Factsheets’ and ‘How It Works’. Community groups had highlighted specific errors regarding grammar and spelling which were rectified. Legal, financial and planning permission information made up the most technical and comprehensive content of the web based DSA. It was imperative that these sections remained unchanged and were presented in their exhaustive form as to guarantee accuracy of information. Instead the web hierarchy layout induced a waterfall schematic to aid usability. Information was initially presented with a brief introduction of technical content and the user decided whether to access more detailed content based on the information provided in the first instance. This was achieved through development of the ‘Legal Structure Decision Guide’ and ‘Funding Sources Decision Guide’ as can be seen in Figures 36 and 37. The decision guides acted as the pathway pages and each section contained a direct link to their associated factsheet. Legal and financial destination webpages were renamed ‘Legal Structure Factsheets’ and ‘Funding Sources Factsheets’ to indicate the level of technical content associated with each. Figure 38 compares the previous prototype destination page design with the new sustainablecommunities.ie fact sheet design.

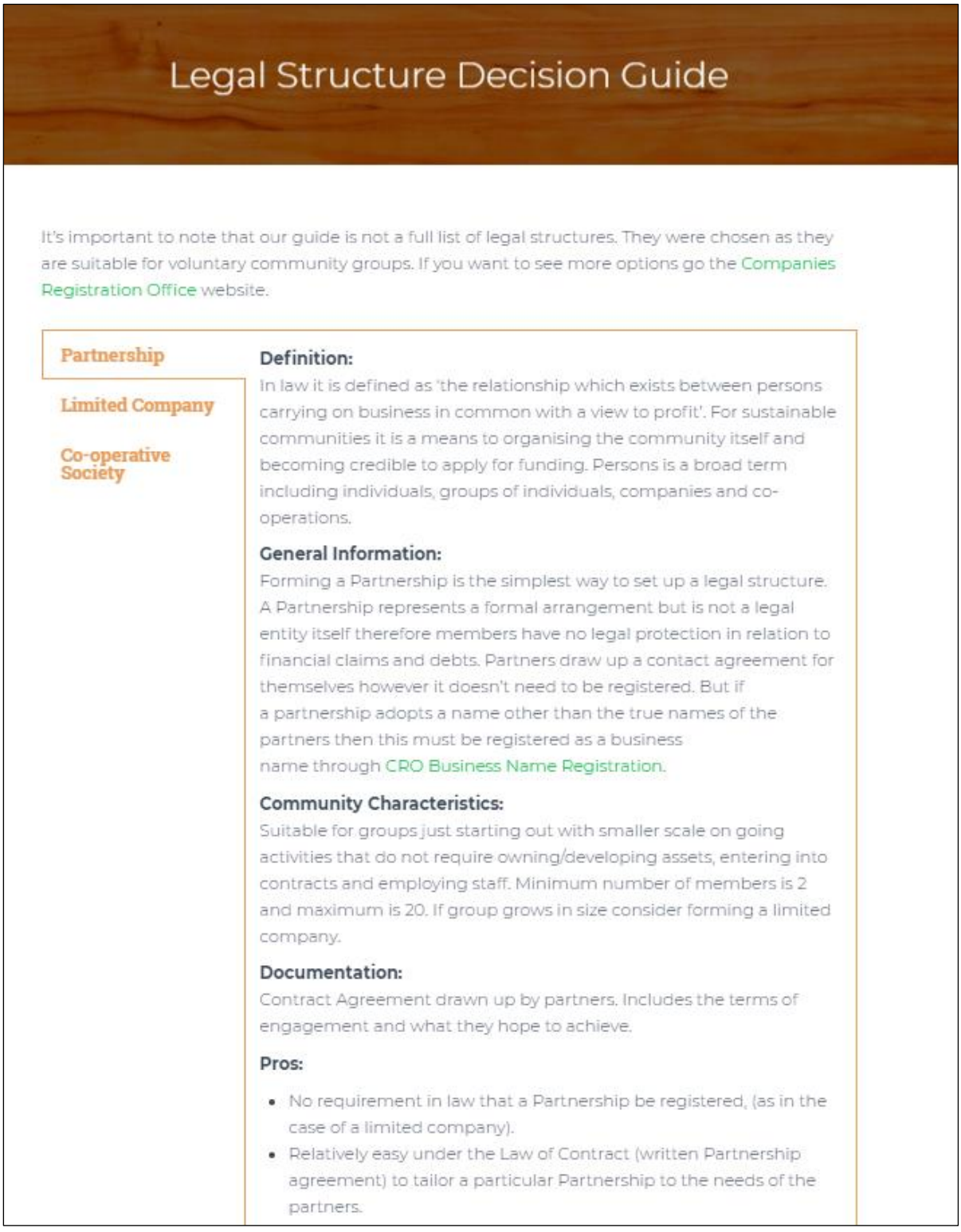


Figure 36: Screenshot of 'Legal Structure Decision Guide' pathway page.

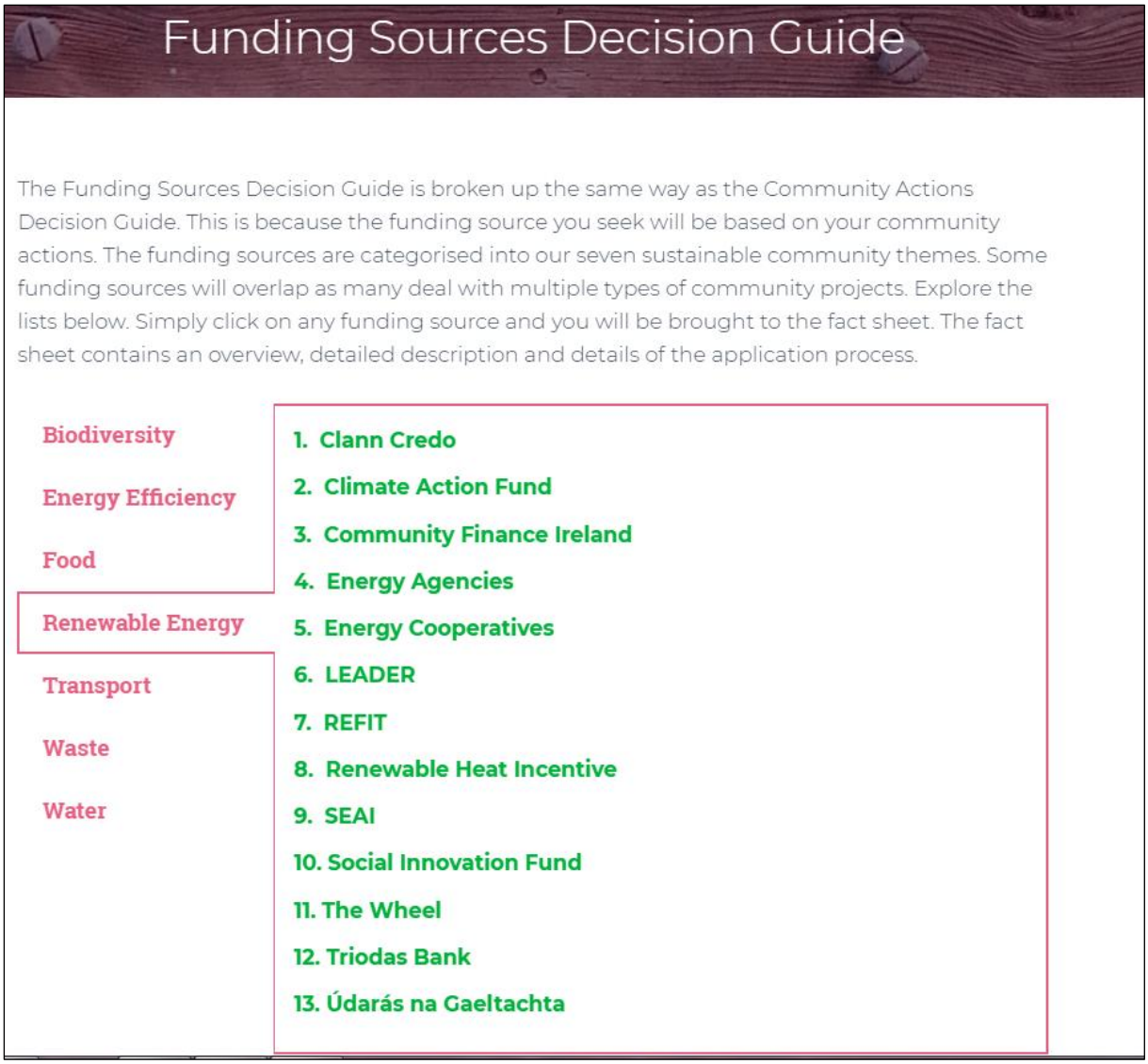


Figure 37: Screenshot of 'Funding Sources Decision Guide' pathway page.

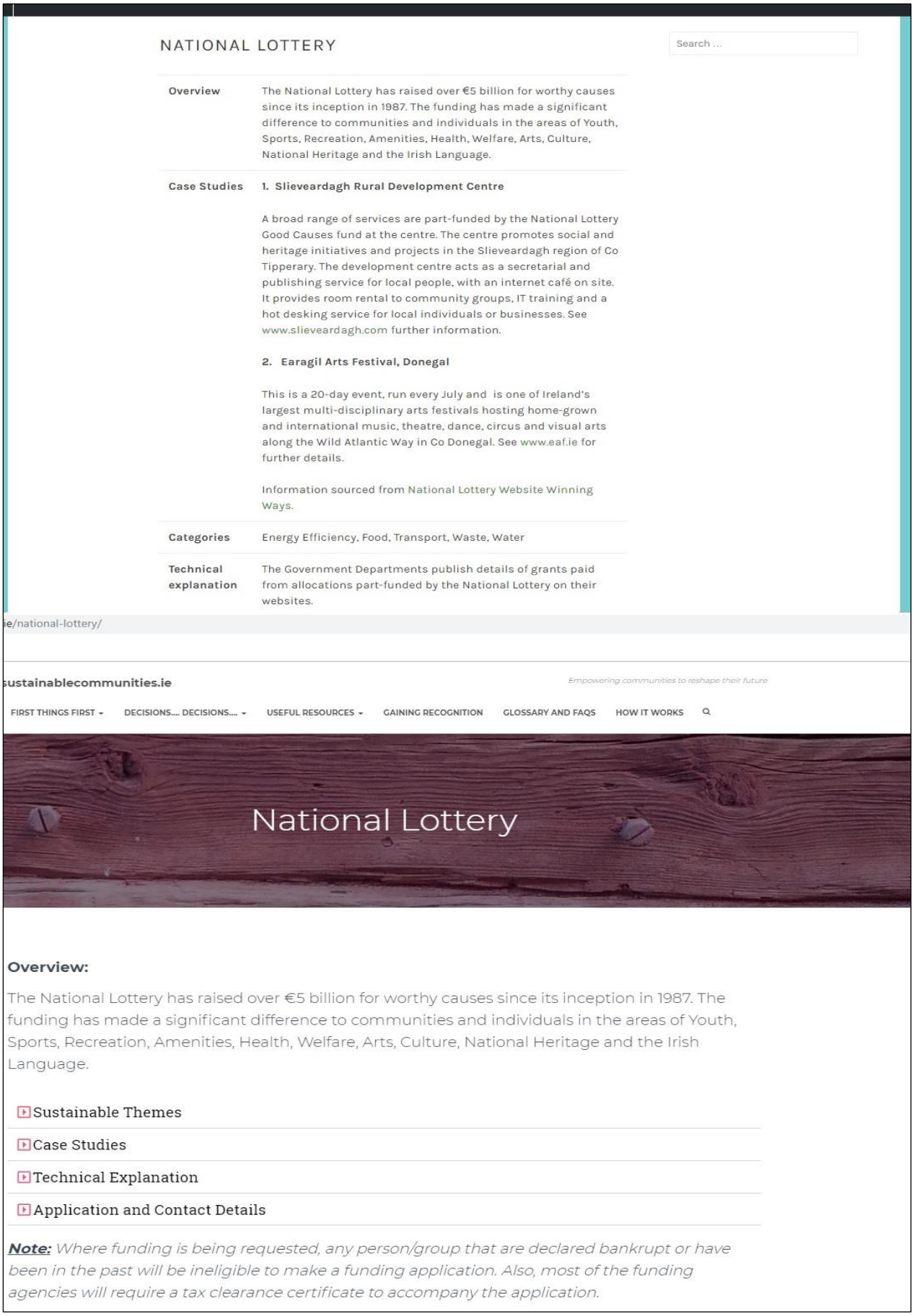


Figure 38: Comparison of 'National Lottery' destination page in original prototype and final website.

The comparison highlights the positive use of expandable links to break up heavy text and enhance interaction. This was essential to promotion of usability and reduction of visual complexity and information overload (Chen 2018). Overall usability was greatly enhanced by means of restructuring and revising content. Modifications made up an intrinsic part of this project. By obtaining user and expert input it was possible to refine and improve the final version based on the intended target audience requirements.

5 Discussion and Evaluation

This research aimed to develop and provide an aid to facilitate local level action towards sustainable development. By adopting a tailored methodology, it was possible to identify barriers associated with community action and establish a process to overcome these obstacles through the construction of a web based Decision Support Aid (DSA). This chapter discusses the effectiveness of methodology used, efficiency and usability of the DSA and implications at the local level.

5.1 Methods Used

The primary goal of this research was to achieve a credible, reliable, and user friendly result, which would provide guidance and elicit knowledge transfer to enhance and support local level sustainable action. The application of a Decision Support Aid (DSA) was a means to accomplishing this. In order to develop a practical DSA, a theoretical driven tailored methodology was established based on the System Development Life Cycle approach and Prototyping (Budde *et al.* 1992; Avison and Fitzgerald 2003; French 2011).

System Development Life Cycle is a traditional waterfall approach to design. Literature provided conflicting interpretations of the technique. The approach has been heavily criticised for neglecting usability criteria by not placing a strong emphasis on end user requirements (Ginige and Murugesan 2001; Avison and Fitzgerald 2003; O'Connor 2009). However, Wiegers (1999) praised the old-fashioned process, stating web projects can benefit from the application of traditional software approaches particularly when dealing with large web development projects and teams. The process provides a systematic structured method which is useful when undertaking large scale projects. Authors have made efforts in advancing the technique with White and Raman (1999) having highlighted the necessity to research user requirements in the planning phase to ensure relevance of content. While Budde *et al.* (1992) and (French 2011) suggested overcoming usability limitations by incorporation of prototyping. Therefore, a hybrid combination of System Development Life Cycle and Prototyping, referred to as the Web Development Life Cycle Approach, was adopted for the purpose of this research and tailored to entail plan, design, construct, evaluate and modify phases of development (French 2011).

Overall the tailored methodology proved to be an effective process in creating an efficient web based decision support aid, which succeeded in achieving the original objective of

information dissemination at the local level. The design and evaluation phases were particularly beneficial. Web Development consistently suggested the utilisation of information architecture to graphically represent the design prior to tackling the technical interior (Jakovljevic *et al.* 2000; Morville and Rosenfeld 2006; Dawson 2010). This was found to be a constructive approach to categorising excessive content and aiding overall structure and navigation. Creation of sitemaps contributed to compartmentalisation of the process and ensured a clear methodical navigation structure. It also demonstrated usefulness in emphasising the necessity to start at the beginning with a straight forward introduction to the main intricate content (Shoup *et al.* 2015). Development of wireframes proved positive in clarifying the user interface features, and refining navigation. Furthermore, the process was extremely effective in prioritising usability by showcasing layouts without imagery and colour, thereby focusing solely on navigation placement, feature placement and pathways. The evaluation phase was critical to the process of development and signifies the importance of prototyping and end-user development techniques, as outlined in other studies. Prototyping was considered an essential approach to constructing high quality websites (Nieveen 1999; Lim *et al.* 2008; Benyon 2010; Sieber *et al.* 2013). This engagement process revealed several important areas which needed to be modified, including the look and feel of the DSA, transparency of content, functionality and overall usability. It was vital to gaining an understanding of end user perceptions and influencing the final development. Collecting evaluation feedback helped refine the final product, making it more likely that the end result would be a useful resource for the target audience.

Although the methodology provided a systematic approach to developing a useful end product there were some limitations. User engagement could have been elicited in the planning stage, however this would have been more resource intensive as literature suggests the use of interviews and surveys (Shoup *et al.* 2015). The literature review on issues to progression of sustainable communities, delivered a strong case for the requirement of legal and financial information to compose the primary part of the content, therefore relevance of content was justified. However, when evaluating the prototype, the communities suggested expanding the scope of content to include more areas of sustainable community development. Furthermore, construction focused on the development of a high fidelity prototype due to its association with greater accuracy of evaluation feedback (Morville and Rosenfeld 2006). A high fidelity prototype is similar in functionality and design to the final

product. It is created using software within the development environment of the final form and is therefore more advanced than low fidelity prototypes, which are generally constructed on paper (Benyon 2010). However, the incorporation of a low fidelity prototype in the design stage may have proved beneficial to gaining user insight prior to building an interactive prototype. Low-fidelity prototypes were described by Sefelin *et al.* (2003) to be the visualization of design ideas at very early stages of the design process (Benyon 2010). Literature has argued the advantages and disadvantages of both (Sefelin *et al.* 2003; Morville and Rosenfeld 2006; Abad *et al.* 2018). Low fidelity saves time by assessing users opinions at an early stage of development, and is useful when there are several design ideas (Sefelin *et al.* 2003). However, there are issues associated with robustness of paper and genuine user feedback as the technique relies on users' imagination to envision the product (Benyon 2010). Generally high fidelity prototypes were more popular because it is easier for users to understand how the system will operate, therefore more accurate user interface improvement and recommendations are obtained (Benyon 2010; Zainuddin and Liu 2011). Incorporation of the two could be a solution to the debate. For example allowing users to evaluate the sitemaps and wireframes in the design stage. In this case, the modification stage may have been less time intensive as user input would have influenced development of the prototype, thereby insinuating less modifications would have been needed. However, engaging the target audience at each stage of the development process would have been too resource and time intensive exceeding the scope of this two-year master's project. To maximise the time frame given, this research was built on previous work carried out in the Centre of Environmental Research (CER) in UL. Byrne *et al.* (2017) conducted one on one interviews with existing sustainable communities in Ireland. This research provided evidence and user input at the beginning of the project when defining the content to be included, therefore minimising the limitations associated with user involvement in the Web Development Life Cycle approach.

To conclude, it was found that the tailored Web Development Life Cycle methodology did pose limitations regarding condensed user input, as stated in literature, and resulted in an intensive modification process. However, the impact of these limitations was reduced by the inclusion of a literature review, including evidence based CER research, to identify the knowledge gap in provision of online information, and utilisation of a high fidelity prototype for evaluation. By adopting these techniques, the objectives of this project were

achieved allowing for the development of a content driven web based decision support aid with direct user input influence on finalised design.

5.2 Decision Support Aid

Review of literature highlighted the problems associated with uptake of sustainable actions at the local level to be lack of guidance in relation to legal obligations and funding sources (Walker 2008; Burch 2010; Feola and Nunes 2014; Byrne *et al.* 2017; Mosannenzadeh *et al.* 2017). There was an overall consensus that communities were not fully aware of the opportunities available to them due to limited dissemination of relevant information at the local level. Traditional environmental decision support technology was aimed at environmental scientists, planners, policy makers, local authorities and environmental managers (Culshaw *et al.* 2006; Matthies *et al.* 2007; Papathanasiou and Kenward 2014). Therefore a distinct opportunity existed to develop a simplified sustainable community focused decision support aid, aimed at the local level, to disseminate information with the aim of overcoming the barriers identified in the review of literature (Matthies *et al.* 2007; Papathanasiou and Kenward 2014; Byrne *et al.* 2017). Furthermore, review of existing environmental aids strengthened the case for the requirement of an accessible, user-friendly web based decision support aid, aimed at Irish communities, by accentuating the lack of online provision of information.

5.2.1 Evaluation Feedback

While review of literature underlined the transparent gap for a local level decision support aid, further work was undertaken to evaluate how the aid would be used in practice, focusing on its relevance to the progression of Irish sustainable communities. Evaluation feedback provided an insight into the genuine uptake opportunity of the online DSA by sustainable communities in Ireland. The aim of the evaluation process was to assess the effectiveness of the DSA for disseminating relevant content to the local level in an easy to understand manner.

5.2.1.1 Effectiveness of Online DSA

There was a general consensus among community groups that the DSA would be well received in the wider community, proving its effectiveness at the local level. Both community groups agreed that the DSA would ‘Encourage community groups to take action’ and ‘Provide inspiration for experienced community groups to take more ambitious action’. The feedback was positive, and insinuated that the dissemination of this

information would assist community groups in carrying out actions at the local level. One community group claimed it was ‘A fantastic resource for both new and existing community groups in learning about what’s possible, how to start and how to take further action’. In relation to practicality of content, feedback suggested that the information presented was useful and relevant. There were further comments including, ‘Sources of finance section excellent’ and ‘Case studies gives a practical aid to understanding potential actions’. Through the evaluation feedback it was concluded that the web based DSA did exhibit significance at the local level and possessed the potential to have positive implications in the wider community.

5.2.1.2 Accessibility and Usability of the Online DSA

When designing a product intended for use by a broad target audience it is essential to ensure ease of use. Literature highlighted extensive characteristics of positive user-interface design which were employed throughout the development process (Hassan and Li 2005; Lee and Kozar 2012; Redish 2012; Garett *et al.* 2016; Chen 2018). However, evaluation feedback suggested enhancements were needed regarding appearance, functionality, navigation, scope of content and usability. Modifications ensued to ensure each area of concern was addressed. Through the use of end-user input an accessible and user-friendly web based DSA was achieved.

5.2.2 Limitations of Evaluation

Although the evaluation provided a positive indicator that the web based DSA would be well received within the wider community, there were a number of limitations which needed to be accounted for. The community groups used in this project were established sustainable communities, meaning they had a pre-existing knowledge and awareness of the information provided in the web based DSA. Therefore, it is difficult to interpret if a new community group or an individual with no environmental background, would benefit from the DSA in real time. Therefore, to assess the genuine potential of the web based DSA a wider focus group is needed.

Secondly, it would have been beneficial to gain user insight at an earlier stage in the project development process, both for user design purpose and clarification of content. Feedback suggested the content was practical and useful but indicted a broader scope was desirable. However, simplifying the complex activity of forming a sustainable community into manageable decision stages was a challenging task in the timeframe of this research

masters. Therefore, attention was focused on the key areas highlighted in the literature review, and previous work conducted in CER, in order to ensure accuracy of information and dissemination in an accessible user-friendly manner. Consequently, in order to meet the full requirements of suggestions posed by the community groups, greater time and resources would need to be employed.

Finally information presented in the web based DSA is dynamic, meaning it is constantly changing. The environmental and sustainability sector is continuously growing as the threat of climate change becomes more prevalent. Therefore, the evaluation process proved success of the DSA at that current moment in time when information was up to date and relevant. However, if the DSA is not maintained and updated on a regular basis links will expire and information could become obsolete.

5.3 Implications of the Online DSA at the Local Level

This research has several implications for the local level. The importance of community led sustainable action cannot be overlooked in the global challenge to mitigate climate change. While top down policy has begun to address the significance of societal change, measures need to be taken to aid bottom up initiatives. The fact that other countries, such as England and Scotland, can produce multiple resources to disseminate and steer local level sustainability actions, is an influential indicator that the practical application of supporting sustainable communities through knowledge transfer is possible, and reason enough for Ireland to follow by example. The primary output of this research was a web based DSA, which breaks down the complex task of forming a sustainable community into manageable decision stages. Through the dissemination of technical, legal and financial information, sourced from professionals, the web based DSA acts as an enabler to local level sustainable action, helping to promote the wider uptake of sustainable communities in Ireland.

6 Evaluation of Research Findings

The potential application of the web based DSA to the local level sustainable community sector in Ireland, was demonstrated successfully, therefore achieving the original aim of this project. This was accomplished through completion of the objectives detailed at the commencement of this study. Through a combination of literature reviews and critical reviews, the barriers to sustainable community progression were identified. Extensive research conducted in relation to decision support technology revealed a gap for the development of an accessible sustainability focused decision support aid, aimed at the local level. A number of comparative analyses were carried out to determine the most appropriate platform for development of an accessible, user friendly and easily updated decision support aid. Consequently, a web based DSA was selected as the delivery mechanism and WordPress was chosen as the development platform. The web based DSA was built by adopting a tailored Web Development Life Cycle approach, which entailed the employment of user-design criteria, evaluation to ensure user-input, and a modification process. The end result was an accessible, user-friendly, web based DSA, which supported the progression of sustainable communities at the local level through knowledge transfer, as of 2018. In achieving the primary aim of this project there were certain factors which contributed to the success and others which acted as limitations.

6.1 Success Factors

The success factors were comprised of the multi-disciplinary research team, consultation with technology experts in UL, evaluation with the community groups, the multi-sectoral Steering Committee, the dynamic WordPress platform, dissemination of work through social media and conference presentations and existence of similar web aids in other countries.

6.1.1 Research Team

The research team was comprised of a multi-disciplinary group of individuals with a broad set of skills and knowledge. The internal academic team consisted of Dr. Bernadette O'Regan, Prof. Richard Moles, Rosemary Byrne and myself. Their expertise and experience in sustainable development practices, environmental policy, settlement sustainability and Irish rural and urban communities was vital to the success of this project (O'Regan *et al.* 2002; Moles *et al.* 2006; O'Doherty *et al.* 2013; Byrne *et al.* 2017). Through previous research undertaken it was possible to determine the major barriers associated

with progression of sustainable action at the local level (Byrne and O'regan 2014; Byrne and O'Regan 2016; Byrne *et al.* 2017). This provided evidence based research that legal, financial and technical matters were primary obstacles to the success of Irish local level action. As the primary content of the DSA was legal and financial information it was essential to elicit the help of legal and financial professionals. Legal and financial information should be crafted by individuals with experience in those sectors as to ensure accuracy of information provision. The legal professional also created a disclaimer which advised users to seek external help from a chartered accountant and solicitor prior to making any final decisions. By working with legal and financial professionals, it was possible to disseminate accurate and practical information to the wider public, from a reliable source.

Research Team	**Members**	**Knowledge and Expertise**
Internal – UL	Dr. Bernadette O'Regan Prof. Richard Moles Rosemary Byrne Anne Bennett	Sustainable development practices, environmental policy, settlement sustainability, Irish communities, environmental management, biodiversity, sustainable resources management and environmental science.
External – Legal Consultant	Dermot Hanratty	Masters of Law and background in dealing with sustainable communities.
External –Managing Director of Captured Carbon and Renewables Manager (financial professionals)	Duncan O'Toole Mark McGarrity	Environment, sustainable development, economics, carbon standards, trading systems, GHG management and biomass.
Steering Committee – EPA and An Taisce	Dr. Dorothy Stewart Dr. Shane Colgan Dr. Damien Ó Tuama	Local sustainability, sustainable urban town planning, sustainable environment, health, cycling policy and sustainable transport.
Ifas		Access to EU wide information on sustainable communities.

Table 12: Summary of research team members and their associated knowledge and expertise.

6.1.2 Consultation with Computer Department in UL

The Department of Electronic and Computer Engineering, and the Department of Computer Science and Information Systems, were a major asset to the project. Informal discussions and consultations, with several members of the departments, helped clarify decisions

regarding methods used for developing the DSA. This contributed to the success of the incorporated methodology and user-friendly design.

6.1.3 Evaluation with Community Groups

The involvement of existing sustainable community groups in Ireland, was essential to gaining an understanding of the possible implications which the DSA could pose in the wider community. While literature highlighted the transparent necessity for a local level sustainability decision support aid, interaction with real sustainable communities was necessary to assert the DSA's potential. The evaluation process provided genuine end user feedback, which helped refine the final product and further enhance the ability of sustainablecommunities.ie to act as an enabler to local level sustainable action.

6.1.4 Steering Committee

The multi-disciplinary and multi-sectoral Steering Committee was particularly important to the operation of this project. Bi-annual meetings ensured the DSA was consistently reviewed throughout the development process. Members from the EPA and An Taisce, with experience in sustainable communities, sustainable urban town planning, environment and health and sustainable transport, provided a critical perspective which highlighted the necessity to target individuals who do not understand the concept of sustainability, in order to increase overall awareness. As well as, assisting existing community groups with more complex issues. Furthermore, observations recorded in the evaluation process facilitated enhancement of the DSA through increased usability, functionality, redesign of appearance and expansion of content.

6.1.5 WordPress Platform

In the search to discover a web based delivery mechanism, which satisfied the DSA goals, WordPress was selected as the most suitable platform. The platform needed to be straight-forward to facilitate regular updating of content by the environmental team, accompanied by extensive help and support opportunities in the form of handbooks, online forums, tutorials and courses, contain extended features to accommodate the pre-determined design layout and low cost to remain within budget. Consequently, WordPress was selected due to the ability to facilitate efficient straight forward website development, in conjunction with customisation and suitable functionality. WordPress provided a dynamic platform, which satisfied the DSA goals making it possible to put drawn out concepts into action for

prototyping purposes, extend functionalities to satisfy the modification process and refine the end product.

6.1.6 Dissemination

Dissemination of research was imperative to engaging the general public and promoting existence of the web based DSA. Social media and environmentally focused national conferences, were seen as an ideal platform to communicate progress of the project. Twitter encouraged interest from Irish energy agencies and sustainability researchers. While conference participation, facilitated awareness raising of the web aid to existing Irish community initiatives.

6.1.7 Existence of Similar Web Aids in Other Countries

A review of existing sustainability and environmental web aids presented a clear indication of the lack of online provision of information at the Irish local level. While England and Scotland exhibited multiple resources aimed at community groups, Ireland had one general website aimed predominantly at charity organisations. The efforts made in England and Scotland were used as models of what could be achieved in this research.

6.2 Limiting Factors

The limiting factors refer to areas of the project which could be improved. They generate expansion of work through future research opportunities. Limitations revolve around the dynamic content, restricted evaluation group, and time constraint.

6.2.1 Dynamic Content

Funding sources made up a critical element of content within the web based DSA. The nature of this content, requires regular updating to ensure details of application forms are renewed and none of the existing sources have become obsolete. This presents a challenge when maintaining the DSA in the future. However, this limitation could be counteracted by the creation of a maintenance plan, which would elect a member of the Centre of Environmental Research the responsibility of reviewing and updating the website every two weeks.

6.2.2 Evaluation Group

The evaluation process only involved a limited number of existing community groups. Restrictions lie in the ability to locate newly formed community groups or interested individuals. If it were possible to target these groups the DSA could be assessed formally

for effectiveness. However, more time would also need to be allocated to obtain realistic outcomes.

6.2.3 Time Constraint

Simplifying the complex process of sustainable community development into a journey of decision stages was a challenging task within the time limits of this research. Therefore, it was essential to focus on key aspects of community sustainability. The emphasis was on dissemination of technical content to overcome information provision barriers, rather than psychological factors such as conflicts of interest and behaviour change. If more time was provided there could be opportunity to explore those areas further, however professional help would also need to be sourced to ensure provision of accurate information.

6.3 Future Work

This research was unique in that it presented an accessible and user-friendly end product, which possesses the potential to act as an enabler to local level sustainable action in Ireland. However, further research needs to be conducted to formally evaluate the web based DSA's effectiveness. Future work could entail an evaluation and trialling process. As noted in Section 6.2.3, the evaluation could be designed to target new sustainable community groups, and individuals with little or no background knowledge in environmental and sustainability matters. In order to capture relevant outcomes and assess the progression of a new community group, a year long trial period would need to be employed. Questionnaires would need to be distributed at the beginning and end of the trialling process, to determine sustainable development awareness, attitude and beliefs towards climate change and sustainable community formation progress. In analysing these outcomes, direct evidence would be established to verify the genuine impact and facilitation capability of the web based DSA, in a wider context beyond existing community groups.

6.4 Conclusion

There is a distinct need for action to be taken if Ireland is to meet future EU 2030 and 2050 emission reduction targets. Previous studies have proven the power of local level bottom up initiatives in reducing GHG emissions, and contributing to mitigation of climate change. However, improving local level sustainability is a major challenge facing Irish society. Literature highlights the barriers associated with uptake of sustainable initiatives at the local level, though few studies have focused on how to overcome these barriers.

This research was unique in that it presented an innovative approach to facilitate local level sustainable action, in Irish communities, through the development of an accessible, user friendly web based decision support aid. This research has proved novelty in a number of ways:

- The utilisation of a multidisciplinary team allowed for the broad scope of sustainable community action to be broken down into several manageable decision stages. The internal academic team provided vital evidence based research that sustainable community action was being inhibited due to the lack of provision of information at the local level, in particular technical, legal and financial related content. The external legal and financial professionals supplied accurate, detailed content allowing technical expert derived information to be disseminated at the local level.

- The deployment of a web platform ensured expert derived content could be accessed nationwide, free of charge, allowing all members of the community equal opportunity to benefit from it.

- The development process of the web based DSA, entailing plan, design, construct, evaluate and modify, was reviewed on a regular basis by the internal academic research team, external legal and financial professionals and the Steering Committee. Therefore, the process of building the DSA was strengthened by the involvement of expert input at each stage of development.

- When compared to previous work carried out in Ireland, with the same intention of provision of information at the local level, this web based DSA is unique in that it

provides an element of interactivity. Previous work focused on the dissemination of pdf documentation and a broader scope involving charity organisations. This work concentrates on sustainable community progression only, and provides an interactive web platform to obtain information, therefore promoting greater engagement and usability.

- Incorporation of a CMS website allowed for the integration of dynamic material and an easy to manage platform. Utilisation of external sources provided a knowledge warehouse of information, and ensured part of this dynamic material would remain updated, based on the external links. Furthermore, employment of a CMS meant the research team could easily access the database and update written content on a regular basis.

- The web based DSA was reviewed and tested by specialists of sustainable development from the EPA and An Taisce. By obtaining essential expert input, the DSA was refined, enhanced and distinguished, through iterative improvements based on their feedback.

- The DSA was reviewed and tested by genuine Irish community members. End-user input was critical to clarifying relevance of content, and enhancing the final version, to ensure it would be utilised by the intended target audience. Evaluation with community members provided validation that the web based DSA did possess the potential to deliver positive implications at the wider community level, therefore acting as an enabler to local level action.

- The methodology used integrated a plan, do, check, act regime, whereby the web based DSA was planned, designed, constructed, evaluated and modified based on evaluation feedback. By abiding to the original schematic, improvement of the end product was achieved through expert and user feedback, which was then acted on through modifications. If further research was to be carried out the same structure of development would ensue, and the web based DSA could undergo continuous improvement through evaluation.

- Finally, previous studies emphasised the transparent opportunity for the implementation of environmental DSS aimed at local level stakeholders, therefore a gap existed for the development of an accessible decision aid. This research has contributed to that knowledge gap by providing an innovative, accessible and user-friendly web based DSA, which disseminates practical information to aid the progression of local level action in Ireland.

In 2015, the Energy White Paper '*Ireland's Transition to a Low Carbon Energy Future*', highlighted the importance of *'citizens and communities*', by emphasising the significant role they will play in achieving Ireland's low carbon transition. In order to incentivise genuine local level community action, more support is needed to empower citizens and communities with the right information to elicit change. This research possesses the potential to act as an enabler to local level sustainable action in Ireland. Through dissemination of relevant and practical technical, legal and financial information, users will be empowered to take action, and incentivise change, moving from passive consumers to active consumers.

Bibliography

- Abad, Z. S. H., Moazzam, S., Lo, C., Lan, T., Frroku, E. and Kim, H. (2018) 'Loud and Interactive Paper Prototyping in Requirements Elicitation: What is it Good for?', in *IEEE 7th International Workshop on Empirical Requirements Engineering (EmpiRE)*, Banff, Canada, 20 Aug IEEE, 16-23.

- Aggarwal, A. K. (2001) 'A Taxonomy of Sequential Decision Support Systems ', in *Proceedings of the 2001 Informing Science* Krakow, 19-22 Jun, 1-12.

- Agrawal, A. and Gibson, C. (1999) 'Enchantment and disenchantment: the role of community in natural resource conservation', *World Development*, 27(4), 629-649.

- Aiken, G. (2012) 'Community Transitions to Low Carbon Futures in the Transition Towns Network (TTN)', *Geography Compass*, 6(2), 89-99.

- Al-Nory, T., Malak (2012) 'Simple Decision Support Tool for University Academic Advising ', in *International Symposium on Information Technology in Medicine and Education (ITME 2012)*, Future University Hokodate, Hokkaido, Japan, 3-5 Aug, Institute of Electrical and Electronics Engineers, 53-57.

- Allen, J. D. and Berry, D. L. (2011) 'Multi-Media Support for Informed/Shared Decision-Making Before and After a Cancer Diagnosis', *Seminars in Oncology Nursing*, 27(3), 192-202.

- Amberd (2017) 'Static HTML websites vs. Dynamic CMS', *Amberd Design & Marketing* [online], 11 Feb, available: https://www.amberddesign.com/static-html-vs-cms/ [accessed 18 Mar 2019].

- An Bord Pleanala (2017) *Inspector's Report PL26.247217.*, Wexford: http://www.pleanala.ie/documents/reports/247/R247217.pdf [accessed 15 Mar 2019].

- Anthony, R. N. (1965) *Planning and Control Systems: A Framework for Analysis* Boston, Mass.: Division of Research, Graduate School of Business Administration, Harvard University.

- Arnott, D. and Pervan, G. (2005) 'A critical analysis of decision support systems research', *Journal of Information Technology*, 20(2), 67-87.

- Avison, D. and Fitzgerald, G. (2003) 'Where now for development methodologies?', *Communications of the ACM*, 46(1), 78-82.

- Barrett, G. (2015) 'Deconstructing community', *Sociologia Ruralis*, 55(2), 182-204.

- Bell, C. and Newby, H. (1979) *Community studies: an introduction to the sociology of the local community*, London: Routledge.

- Benjamins, S. (2019) *How to make a website* [online], available: https://www.sitebuilderreport.com/how-to-make-a-great-website#domains [accessed 31 Mar 2019].

- Benyon, D. (2010) *Designing interactive systems a comprehensive guide to HCI and interaction design*, 2nd ed., Harlow: Addison-Wesley.

- Berglund, T., Gericke, N. and Chang Rundgren, S. N. (2014) 'The implementation of education for sustainable development in Sweden: investigating the sustainability consciousness among upper secondary students', *Research in Science and Technological Education*, 32(3), 318-339.

- Bhargava, H. K., Power, D. J. and Sun, D. (2007) 'Progress in Web-based decision support technologies', *Decision Support Systems*, 43(4), 1083-1095.

- Bhargava, H. K., Sridhar, S. and Herrick, C. (1999) 'Beyond spreadsheets: tools for building decision support systems', *Computer*, 32(3), 31-39.

- Boeve-de Pauw, J., Gericke, N., Olsson, D. and Berglund, T. (2015) 'The Effectiveness of Education for Sustainable Development', *Sustainability*, 7(11), 15693-15717.

- Bonnett, M. (1999) 'Education for sustainable development: A coherent philosophy for environmental education?', *Cambridge Journal of Education*, 29(3), 313-324.

- Bradshaw, T. (2013) 'The post place community: contributions to the debate about the definition of community' in Brennan, M. A., Bridger, J. C. and Alter, T. R., eds., *Theory, practice and community development*, London: Routledge, 11-24.

- Brandon, P. S. (1999) 'Sustainability in management and organization: the key issues?', *Building Research & Information*, 27(6), 390-396.

- BSI (2011) *Micro guide for developing sustainable communities*, London, England: http://shop.bsigroup.com/upload/265921/BSI_BS8904_Sustainable_Communities_Guidance_A48pp_AW_LR.pdf [accessed 22 Mar 2019].

- Budde, R., Kautz, K., Kuhlenkamp, K. and Züllighoven, H. (1992) 'Prototyping' in *Prototyping: An Approach to Evolutionary System Development*, Berlin, Heidelberg: Springer Berlin Heidelberg, 33-46.

- Buehlmann, U., Ragsdale, C. T. and Gfeller, B. (2000) 'A spreadsheet-based decision support system for wood panel manufacturing', *Decision Support Systems*, 29(3), 207-227.

- Burch, S. (2010) 'Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in British Columbia, Canada', *Global Environmental Change*, 20(2), 287-297.

- Byrne, R., Byrne, S., Ryan, R. and O'Regan, B. (2017) 'Applying the Q-method to identify primary motivation factors and barriers to communities in achieving decarbonisation goals', *Energy Policy*, 110(Supplement C), 40-50.

- Byrne, S. and O'Regan, B. (2016) 'Material flow accounting for an Irish rural community engaged in energy efficiency and renewable energy generation', *Journal of Cleaner Production*, 127, 363-373.

- Byrne, S. and O'regan, B. (2014) 'Attitudes and actions towards recycling behaviours in the Limerick, Ireland region', *Resources, Conservation & Recycling*, 87, 89-96.

- Cabot, J. (2018) 'WordPress: A Content Management System to Democratize Publishing', *IEEE Software*, 35(3), 89-92.

- Cameron, M., Tan, J., McLellan, C., O'Neil, A. I., Reed, A., Henderin, C., Dellavalle, R. P. and Boyal, S. (2018) 'Development of Patient Decision Aids for Plaque Psoriasis and Acne', *Dermatology online journal*, 24(7), 1-20.

- Carof, M. and Godinot, O. (2018) 'A free online tool to calculate three nitrogen-related indicators for farming systems', *Agricultural Systems*, 162(C), 28-33.

- Carragher, V. (2011) *Using an ecological footprint to operate and maintain a short-term self regulating and community based environmental programme*, unpublished thesis University of Limerick.

- Carson, R. and Darling, L. (1962) *Silent Spring*, Boston: Houghton Mifflin Company.

- Charnock, G. (2007) 'Grass roots village action inspires other communities to take on the challenge of climate change', *Local Economy*, 22(1), 75-79.

- Chen, M. (2018) 'Improving website structure through reducing information overload', *Decision Support Systems*, 110, 84-94.

- Citizens' Assembly (2018) *Third Report and Recommendations of the Citizens' Assembly How the State can make Ireland a Leader in Tackling Climate Change*, Ireland:https://www.citizensassembly.ie/en/How-the-State-can-make-Ireland-a-leader-in-tackling-climate-change/Final-Report-on-how-the-State-can-make-Ireland-a-leader-in-tackling-climate-change/Climate-Change-Report-Final.pdf [accessed 15 Mar 2019].

- Clark, W. W. (2010) *Sustainable Communities* London: Springer.

- Clobridge, A. (2016) 'WordPress: The Most Popular (Open) Web Content Management System', *Online Searcher*, 40(5), 60-62.

- CMS Platforms (2019) *CMS comparison: A review of the best platforms* [online], available:https://www.ionos.com/digitalguide/hosting/cms/cms-comparison-a-review-of-the-best-platforms/ [accessed 25 Mar 2019].

- Cohen, A. (1985) *Symbolic construction of community key ideas*, London: Routledge.

- Community Energy Plus (2019) *Community Energy Toolkit* [online], available: https://www.cep.org.uk/help-for-communities/community-energy-toolkit/ [accessed 25 Mar 2019].

- Community Places (2012) *Community Planning Toolkit* [online], available: https://www.communityplanningtoolkit.org/ [accessed 25 Mar 2019].

- Community Tool Box (2018) *Community Tool Box* [online], available: https://ctb.ku.edu/en [accessed 25 Mar 2019].

- Cooke, S. and Slack, N. (1984) *Making management decisions*, Englewood Cliffs, London: Prentice Hall.

- Cortés, U., Sànchez-Marrè, M., Ceccaroni, L., R-Roda, I. and Poch, M. (2000) 'Artificial intelligence and Environmental Decision Support Systems', *Applied Intelligence*, 13(1), 77-91.

- Courage, C. (2015) *Understanding your users : a practical guide to user research methods*, 2nd ed., Amsterdam: Elsevier, Morgan Kaufmann.

- Courtney, J. F. (2001) 'Decision making and knowledge management in inquiring organizations: toward a new decision-making paradigm for DSS', *Decision Support Systems*, 31, 17-38.

- Coutinho-Rodrigues, J., Simão, A. and Antunes, C. H. (2011) 'A GIS-based multicriteria spatial decision support system for planning urban infrastructures', *Decision Support Systems*, 51(3), 720-726.

- Culshaw, M. G., Nathanail, C. P., Leeks, G. J. L., Alker, S., Bridge, D., Duffy, T., Fowler, D., Packman, J. C., Swetnam, R., Wadsworth, R. and Wyatt, B. (2006) 'The role of web-based environmental information in urban planning—the environmental information system for planners', *Science of The Total Environment*, 360(1), 233-245.

- Daly, M. (2016) 'Decision support: a matter of information supply and demand', *Journal of Decision Systems*, 25(sup1), 216-227.

- Darejeh, A. and Singh, D. (2013) 'A review on user interface design principles to increase software usability for users with less computer literacy', *Journal of Computer Science*, 9(11), 1443-1450.

- Davis, J. R., Nanninga, P. M., Biggins, J. and Laut, P. (1991) 'Prototype decision support system for analyzing impact of catchment policies', *Journal of Water Resources Planning and Management*, 117(4), 399-414.

- Dawson, A. (2010) *Getting StartED Building Websites*, Berkeley, Calif: Apress.

- DCCAE (2018) *National Adaptation Framework, Planning for a Climate Resilient Ireland*, Dublin, Ireland: https://www.dccae.gov.ie/documents/National%20Adaptation%20Framework.pdf [accessed 04 Apr 2019].

- DCENR (2015) *Ireland's Transition to a Low Carbon Energy Future 2015-2030*, Dublin, Ireland: https://www.dccae.gov.ie/en-ie/energy/publications/Documents/2/Energy%20White%20Paper%20-%20Dec%202015.pdf [accessed 22 Mar 2019].

- De Matos, P., Cham, J. A., Cao, H., Alcántara, R., Rowland, F., Lopez, R. and Steinbeck, C. (2013) 'The Enzyme Portal: a case study in applying user-centred design methods in bioinformatics', *BMC bioinformatics*, 14(1), 103.

- Delanty, G. (2003) *Community*, London: Routledge.

- Dick, J. (2017) 'Organizing Website Content ', *Venturi-Web* [online], 25 June available: https://venturi-web-design.com/planning-a-website-organizing-your-content-a-short-guide-for-beginners/ [accessed 01 Mar 2019].

- Dicks, L. V., Walsh, J. C. and Sutherland, W. J. (2014) 'Organising evidence for environmental management decisions: a '4S' hierarchy', *Trends in Ecology and Evolution*, 29(11), 607-613

- Díez, E. and McIntosh, B. S. (2009) 'A review of the factors which influence the use and usefulness of information systems', *Environmental Modelling and Software*, 24(5), 588-602.

- Dinnie, E. and Holstead, K. L. (2018) 'The influence of public funding on community-based sustainability projects in Scotland', *Environmental Innovation and Societal Transitions*, 29, 25-33.

- Döberl, G., Ortmann, M. and Frühwirth, W. (2013) 'Introducing a goal-oriented sustainability assessment method to support decision making in contaminated site management', *Environmental Science and Policy*, 25, 207-217.

- Dous, Z. M. Z., Sewisy, A. A. and Seddik, M. F. (2018) 'Decision Making Techniques and Tools Based On Decision Support System', *Journal Of Engineering Research And Application*, 8(3), 9-16.

- Drake, L. and Lawson, L. J. (2015) 'Results of a US and Canada community garden survey: shared challenges in garden management amid diverse geographical and organizational contexts', *Agriculture and Human Values*, 32(2), 241-254.

- Drummond, H. (1991) *Effective Decision Making: A Practical Guide for Management*, London: Kogan Page.

- EPA (2016) *Ireland's Environment 2016 - An Assessment* Wexford Environmental Protection Agency, Ireland: http://www.epa.ie/pubs/reports/indicators/SoE_Report_2016.pdf [accessed 01 Mar 2019].

- EPA (2018) *Ireland's Greenhouse Gas Emissions Projections 2017-2035*, Dublin, Ireland: http://www.epa.ie/pubs/reports/air/airemissions/ghgprojections2017-2035/EPA_2018_GHG_Emissions_Projections_Summary_Report.pdf [accessed 27 Mar 2019].

- ERSI (2017) *Consumer Sentiment Index, December 2016* Dublin https://www.esri.ie/publications/consumer-sentiment-index-december-2016/ [accessed December 2018].

- Ewing, B. and Baker, E. (2009) 'Development of a Green Building Decision Support Tool: A Collaborative Process', *Decision Analysis*, 6(3), 172-185.

- Fahy, F. and O'Cinneide, M. (2008) 'Developing and testing an operational framework for assessing quality of life', *Environmental Impact Assessment Review*, 28(6), 366-379.

- Fang, X. and Holsapple, C. W. (2007) 'An empirical study of web site navigation structures' impacts on web site usability', *Decision Support Systems*, 43(2), 476-491.

- Feghali, T., Zbib, I. and Hallal, S. (2011) 'A Web-based Decision Support Tool for Academic Advising ', *Educational Technology & Society*, 14(1), 82-94.

- Feola, G. and Nunes, R. (2014) 'Success and failure of grassroots innovations for addressing climate change: The case of the transition movement', *Global Environmental Change*, 24(1), 232-250.

- Ferenhof, H. A., Vignochi, L., Selig, P. M., Lezana, Á. G. R. and Campos, L. M. S. (2014) 'Environmental management systems in small and medium-sized enterprises: an analysis and systematic review', *Journal of Cleaner Production*, 74(C), 44-53.

- Filip, F. G. (2008) 'Decision support and control for large-scale complex systems', *Annual Reviews in Control*, 32(1), 61-70.

- Fitzgerald, B. G., O'doherty, T., Moles, R. and O'regan, B. (2012) 'A quantitative method for the evaluation of policies to enhance urban sustainability', *Ecological Indicators*, 18, 371-378.

- Fleisher, L., Ruggieri, D. G., Miller, S. M., Manne, S., Albrecht, T., Buzaglo, J., Collins, M. A., Katz, M., Kinzy, T. G., Liu, T., Manning, C., Charap, E. S., Millard, J., Miller, D. M., Poole, D., Raivitch, S., Roach, N., Ross, E. A. and Meropol, N. J. (2014) 'Application of best practice approaches for designing decision support tools: The preparatory education about clinical trials (PRE-ACT) study', *Patient Education and Counseling*, 96(1), 63-71.

- Flynn, V. and Williams, D. W. (1998) 'A Framework for Understanding the Factors that Influence the Decision-Making Behaviour of IT Managers as an Aid to Improved Competence in Decision-Making', in *4th International Competence-Based Management Conference*, Oslo, Norway.

- Forrest, N. and Wiek, A. (2014) 'Learning from success—Toward evidence-informed sustainability transitions in communities', *Environmental Innovation and Societal Transitions*, 12, 66-88.

- Fox, J. and Das, S. (2000) *Safe and Sound: Artificial Intelligence in Hazardous Applications* Menlo Park, Calif: AAAI Press/MIT Press.

- Franklin, A., Newton, J. and McEntee, J. C. (2011) 'Moving beyond the alternative: sustainable communities, rural resilience and the mainstreaming of local food', *Local Environment*, 16(8), 771-788.

- French, A. (2011) 'Web Development Life Cycle: A New Methodology for Developing Web Applications', *Journal of Internet Banking and Commerce*, 16(2), 1-11.

- Galletta, D. F., Henry, R. M., McCoy, S. and Polak, P. (2006) 'When the wait isn't so bad: The interacting effects of website delay, familiarity, and breadth', *Information Systems Research*, 17(1), 20-37.

- Gardner, S. (2011) 'Malmö, Sweden', *Municipal World*, 121(8), 5-6,48.

- Garett, R., Chiu, J., Zhang, L. and Young, S. D. (2016) 'A Literature Review: Website Design and User Engagement', *Online journal of communication and media technologies*, 6(3), 1-14.

- Garrido-Baserba, M., Molinos-Senante, M., Abelleira-Pereira, J. M., Fdez-Güelfo, L. A., Poch, M. and Hernández-Sancho, F. (2015) 'Selecting sewage sludge treatment alternatives in modern wastewater treatment plants using environmental decision support systems', *Journal of Cleaner Production*, 107, 410-419.

- Giddings, B., Hopwood, B. and O' Brien, G. (2002) 'Environment, economy and society: fitting them together into sustainable development', *Sustainable Development*, 10(4), 187-196.

- Ginige, A. and Murugesan, S. (2001) 'The essence of web engineering - managing the diversity and complexity of web application development', *IEEE MultiMedia*, 8(2), 22-25.

- Goldsborough, R. (2012) 'Writing for the Web', *Tech Directions*, 72(5), 12.

- Gorry, G. A. and Scott Morton, S., Michael (1971) 'A Framework for Management Information Systems ', *Sloan Management Review*, 13(1), 55-70.

- Gretzel, U., Yuan, Y.-L. and Fesenmaier, D. R. (2000) 'Preparing for the New Economy: Advertising Strategies and Change in Destination Marketing Organizations', *Journal of Travel Research*, 39(2), 146-156.

- Guariso, G. and Werthner, H. (1989) *Environmental decision support systems*, Chichester, England: E. Horwood, Halsted Press.

- Hamouda, M. A. (2011) 'A decision support system to select sustainable decentralised drinking water treatment systems', in *Proceedings of the IWA Symposium on Systems Analysis and Integrated Assessment (WATERMATEX)*, San Sebastian, Spain, 20-22 Jun 184-192.

- Hanratty, D. (2019a) *Planning Procedure*, Internal Legal Consultant Report, unpublished.

- Hanratty, D. (2019b) *Social Enterprise and Charitable Status Summary*, Internal Legal Consultant Report, unpublished.

- Hanratty, D. (2019c) *Summary of Legal Supports for Community Groups* Internal Legal Consultant Report, unpublished.

- Harrison, J. D., Kanade, S. S. and Toney, A. H. (2004) 'Agriculture environmental management information system: An online decision support tool', *Journal of Extension*, 42(1).

- Hassan, S. and Li, F. (2005) 'Evaluating the Usability and Content Usefulness of Web Sites: A Benchmarking Approach', *Journal of Electronic Commerce in Organizations*, 3(2), 46-67.

- Haubrich, H., Reinfried, S. and Schleicher, Y. (2008) 'Lucerne Declaration on Geographical Education for Sustainable Development', *Interaction*, 36(1), 39-43.

- Heaslip, E., J. Costello, G. and Lohan, J. (2016) 'Assessing good-practice frameworks for the development of sustainable energy communities in Europe: Lessons from Denmark and Ireland', *Journal of Sustainable Development of Energy, Water and Environment Systems*, 4(3), 307-319.

- Hedenus, F., Persson, U. M. and Sprei, F. (2016) *Sustainable development - History, definitions and the role of the engineer*, Gothenburg: Studentlitteratur AB.

- Heng, C. (2011) *Tips on Choosing a Good Domain Name* [online], available: https://www.thesitewizard.com/archive/domainname.shtml [accessed 28 Feb 2019].

- Hielscher, S., Seyfang, G. and Smith, A. (2011) 'Community Innovation for Sustainable Energy ', *CSERGE Working Paper 2011-03*.

- Hopkins, R. (2008) *The Transition Handbook: From Oil Dependency to Local Resilience*, Devon, England: Green Books Ltd.

- Hsieh, Y.-C. (2012) 'Hotel companies' environmental policies and practices: a content analysis of their web pages', *International Journal of Contemporary Hospitality Management*, 24(1), 97-121.

- Huang, G. H., Qin, X. S., Sun, W., Nie, X. H. and Li, Y. P. (2009) 'An optimisation-based environmental decision support system for sustainable development in a rural area in China ', *Civil Engineering and Environmental Systems*, 26(1), 65-83.

- Hubble, A., Murphy, D. and Perry, C. (2011) 'From Static and Stale to Dynamic and Collaborative: The Drupal Difference', *Information Technology and Libraries*, 30(4), 190-197.

- International Organization for Standardization (2016) *ISO 37101:2016 Sustainable development in communities- management system for sustainable development - requirements with guidance for use*, Geneva: International Organization for Standardization.

- IPCC (2014) *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Geneva, Switzerland: https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf [accessed 04 Apr 2019].

- IPCC (2018) *Strengthening and Implementing the Global Response , An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts*

to eradicate poverty, World Meteorological Organization, Geneva, Switzerland: https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf [accessed 04 Apr 2019].

- Isigonis, P., Critto, A., Stefan, M., Zabeo, A., Ciffroy, P. and Marcomini, A. (2019) '"AMORE" Decision Support System for probabilistic Ecological Risk Assessment - Part I: Exposure and risk assessment of the case study on cyanide', *Science of The Total Environment*, 648, 693-702.

- ISO (2018) *ISO 9241-11:2018 Ergonomics of human-system interaction*, British Standards Institute.

- Jakovljevic, M., Ankiewicz, P. and Swardt, E. d. (2000) 'Technological stages in the system development life cycle: an application to Web page design', *South African Journal of Information Management*, 2(2/3).

- Jiang, P., Chen, Y., Xu, B., Dong, W. and Kennedy, E. (2013) 'Building low carbon communities in China: the role of individual's behaviour change and engagement', *Energy Policy*, 60, 611-620.

- Jiménez Iglesias, L., Aguilar, C., Sánchez, L. and Pérez - Montoro Gutiérrez, M. (2018) 'User experience and the media: the three-click rule on newspaper websites for smartphones', *Revista Latina de Comunicación Social*, 73, 595-613.

- Johnson, S. (1992) *The Earth Summit: the United Nations Conference on Environment and Development (UNCED)*, London, Boston: Graham & Trotman/Martinus Nijhoff.

- Jones, K. and Farrington, P.-A. (2011) 'Getting Started with WordPress', *Library Technology Reports*, 47(3), 8-15,2.

- Joseph, C. (2013) 'Understanding sustainable development concept in Malaysia', *Social Responsibility Journal*, 9(3), 441-453.

- Karlins, D. and Sahlin, D. (2019) *How to create profiles of your websites target audience* [online], available: https://www.dummies.com/web-design-development/site-development/how-to-create-profiles-of-your-websites-target-audience/ [accessed 20 Mar 2019].

- Kirwan, J., Ilbery, B., Maye, D. and Carey, J. (2013) 'Grassroots social innovations and food localisation: An investigation of the Local Food programme in England', *Global Environmental Change*, 23(5), 830-837.

- Lazarus, S., Seedat, M. and Naidoo, A. V. (2016) 'Community building: challenges of constructing community' in Bond, M. A., Keys, C. B., Serrano-Garcia, I. and Shinns, B., eds., *APA Handbook of Community Psychology*, Washington D.C.: APA, 215-234.

- Leary, S. (2009) 'About WordPress' in *Beginning WordPress 3*, Berkeley, CA: Apress, 1-14.

- Lee, Y. and Kozar, K. A. (2012) 'Understanding of website usability: Specifying and measuring constructs and their relationships', *Decision Support Systems*, 52(2), 450-463.

- Liao, Z., Xu, Z., Wang, D., Lu, S. and Hannam, P. M. (2011) 'River environmental decision support system development for Suzhou Creek in Shanghai', *Journal of Environmental Management*, 92(9), 2211-2221.

- Lim, C. P. and Jain, L. C. (2010) 'Advances in Intelligent Decision Making' in Jain, L. C. and Lim, C. P., eds., *Handbook on Decision Making: Vol 1: Techniques and Applications*, Berlin, Heidelberg: Springer Berlin Heidelberg, 3-28.

- Lim, Y., Stolterman, E. and Tenenberg, J. (2008) 'The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas', *ACM Transactions on Computer-Human Interaction (TOCHI)*, 15(2), 1-27.

- Lindsey, T. C. (2011) 'Sustainable principles: common values for achieving sustainability', *Journal of Cleaner Production*, 19(5), 561-565.

- Local Enegy Scotland (2019) *CARES Toolkit - Local Energy Scotland* [online], available: https://www.localenergy.scot/resources/cares-toolkit/ [accessed 25 Mar 2019].

- Louw, C. (2017) 'Good, better, best practise - a comparative analysis of Official Destination Websites', *African Journal of Hospitality, Tourism and Leisure*, 6(3), 1-13.

- Lozano, R. (2006) 'Incorporation and institutionalization of SD into universities: breaking through barriers to change', *Journal of Cleaner Production*, 14(9), 787-796.

- Lynch, P. J. and Horton, S. (2008) *Web style guide : basic design principles for creating Web sites*, 3rd ed., New Haven, Conn: Yale University Press.

- Lyon, L. and Driskell, R. (2011) *The community in urban society*, 2 ed., Illinois: Waveland Press.

- Macdorman, K. F., Whalen, T. J., Ho, C.-C. and Patel, H. (2011) 'An Improved Usability Measure Based on Novice and Expert Performance', *International Journal of Human-Computer Interaction*, 27(3), 280-302.

- Makrakis, V. (2010) 'ICT- enabled reorienting teacher education to address sustainable development: a case study', in *7th Pan-Hellenic Conference with International Participation «ICT in Education* Korinthos, Greece, 23-26 Sep, 138-143.

- Mannarini, T. and Fedi, A. (2009) 'Multiple senses of community: the experience and meaning of community', *Journal of Community Psychology*, 37(2), 211-227.

- Markard, J., Raven, R. and Truffer, B. (2012) 'Sustainability transitions: An emerging field of research and its prospects', *Research Policy*, 41(6), 955-967.

- Matthies, M., Giupponi, C. and Ostendorf, B. (2007) 'Environmental decision support systems: Current issues, methods and tools', *Environmental Modelling & Software*, 22(2), 123-127.

- Mazloomi, M. and Hassan, A. S. (2008) 'Sustainable Development: Divergences and Complexities In Interpretation.', in *2nd International Conference on Built Environment in Developing Countries*, Universiti Sains Malaysia, Pulau Pinang, 3rd - 4th Dec, 310-322.

- McCaffery, K., Irwig, L. and Bossuyt, P. (2007) 'Patient Decision Aids to Support Clinical Decision Making: Evaluating the Decision or the Outcomes of the Decision', *Medical Decision Making*, 27(5), 619-625.

- McGarrity, M. and O'Toole, D. (2019) *Irish Financing for Community Sustainable Action*, Internal Captured Carbon Report, unpublished.

- McGranahan, G. and Satterthwaite, D. (2014) *Urbanisation concepts and trends* IIED Working Paper. IIED, London: http://www.jstor.org/stable/resrep01297 [accessed 04 Apr 2019].

- McLaren Loring, J. (2007) 'Wind energy planning in England, Wales and Denmark: Factors influencing project success', *Energy Policy*, 35(4), 2648-2660.

- McMillan, D. and Chavis, D. (1986) 'Sense of community: a definition and theory', *Journal of Community Psychology*, 14, 6-23.

- Mening, R. (2018) *WordPress vs Joomla vs Drupal (Comparison)* [online], available: https://websitesetup.org/cms-comparison-wordpress-vs-joomla-drupal/ [accessed 18 Mar 2019].

- Middlemiss, L. and Parrish, B. D. (2010) 'Building capacity for low-carbon communities: The role of grassroots initiatives', *Energy Policy*, 38(12), 7559-7566.

- Middleton, P. (2018) 'Sustainable living education: Techniques to help advance the renewable energy transformation', *Solar Energy*, 174, 1016-1018.

- Midin, M., Joseph, C. and Mohamad, N. (2016) 'Advancing Sustainable Development in the Public Sector via Stakeholders' Engagement Disclosure Website', *Procedia - Social and Behavioral Sciences*, 224(Supplement C), 93-100.

- Mohamed, A., Reynolds, E., Sankar, C. S., Raju, P. K. and B.S., N. K. (2012) 'Glazing Made Simple: A Decision Support System Tool Using MS Excel VBA', in *2012 ASEE Annual Conference & Exposition*, San Antonio, Texas, 10-13 Jun ASEE Conferences, 25.670.1 - 25.670.19.

- Moles, R., Foley, W. and O'Regan, B. (2006) 'The environmental impacts of private car transport on the sustainability of Irish settlements' in Davenport, J. and Davenport, J. L., eds., *The Ecology of Transportation: Managing Mobility for the Environment*, Dordrecht: Springer Netherlands, 119-164.

- Molinos-Senante, M., Garrido-Baserba, M., Reif, R., Hernández-Sancho, F. and Poch, M. (2012) 'Assessment of wastewater treatment plant design for small communities: Environmental and economic aspects', *Science of The Total Environment*, 427-428, 11-18.

- Morville, P. and Rosenfeld, L. (2006) *Information Architecture for the World Wide Web* 3rd ed., Sebastopol, Calif.: O'Reilly.

- Mosannenzadeh, F., Di Nucci, M. R. and Vettorato, D. (2017) 'Identifying and prioritizing barriers to implementation of smart energy city projects in Europe: An empirical approach', *Energy Policy*, 105, 191-201.

- Mulgan, G. (2006) 'The process of social innovation', *Innovations*, 1(2), 145-162.

- Mulugetta, Y., Jackson, T. and van der Horst, D. (2010) 'Carbon reduction at community scale', *Energy Policy*, 38(12), 7541-7545.

- Murano, P. and Lomas, T. J. (2015) 'Menu Positioning on Web Pages. Does it Matter?', *International Journal of Advanced Computer Science and Applications*, 6(4), 141-147.

- Nieveen, N. (1999) 'Prototyping to Reach Product Quality' in van den Akker, J., Branch, R. M., Gustafson, K., Nieveen, N. and Plomp, T., eds., *Design Approaches and Tools in Education and Training*, Dordrecht: Springer Netherlands, 125-135.

- Nilsson, M., Jordan, A., Turnpenny, J., Hertin, J., Nykvist, B. and Russel, D. (2008) 'The use and non-use of policy appraisal tools in public policy making: An analysis of three European countries and the European Union', *Policy Sciences*, 41(4), 335-355.

- Nižetić, I., Fertalj, K. and Milašinović, B. (2007) 'An Overview of Decision Support System Concepts ', in *18th International Conference on Information and Intelligent Systems*, Varaždin, Hrvatska, 12-14 Sep, 251-256.

- Nof, S. Y., Morel, G., Monostori, L., Molina, A. and Filip, F. (2006) 'From plant and logistics control to multi-enterprise collaboration', *Annual Reviews in Control*, 30(1), 55-68.

- O'Connor, R. V. (2009) 'Exploring the role of usability in the software process a study of Irish software SMEs', *Communications in Computer and Information Science*, 42(5), 161-172.

- O'Regan, B., Moles, R., Kelly, R., Ravetz, J. and McEvoy, D. (2002) 'Developing indicators for the estimation of sustainable settlement size in Ireland', *Environmental Management and Health*, 13(5), 450-466.

- O'Doherty, T., Fitzgerald Brian, G., Moles, R. and O'Regan, B. (2013) 'A novel method for feasibility testing urban sustainable development policies', *Spatium*, 2013(30), 1-6.

- Onyx, J. and Leonard, R. J. (2011) 'Complex systems leadership in emergent community projects', *Community Development Journal*, 46(4), 493-510.

- Ornetzeder, M. and Rohracher, H. (2013) 'Of solar collectors, wind power, and car sharing: Comparing and understanding successful cases of grassroots innovations', *Global Environmental Change*, 23(5), 856-867.

- Papathanasiou, J. and Kenward, R. (2014) 'Design of a data-driven environmental decision support system and testing of stakeholder data-collection', *Environmental Modelling and Software*, 55(C), 92-106.

- Parker, C. G. (2004) 'Decision Support Tools: Barriers to Uptake and Use', in *Advances in Applied Biology: Providing New Opportunities for Consumers and Producers in the 21st Century*, St. Catherine's College, University of Oxford, England, 15-17 Dec, Wellesbourne, Association of Applied Biologists, 31-41.

- Patel, N. (2019) 'How to Use the Psychology of Color to Increase Website Conversions', [online], 25 Mar available: https://neilpatel.com/blog/psychology-of-color-and-conversions/ [accessed 25 Mar 2019].

- Patel, S. K., Rathod, D. V. R. and Prajapati, J. B. (2011) 'Performance Analysis of Content Management Systems Joomla, Drupal and WordPress', *International Journal of Computer Applications*, 21(4), 39-43.

- Pearce, D., Markandya, A. and Barbier, E. (1989) *Blueprint for a green economy - a report for the UK department of the environment*, London: Earthscan.

- Pearson, J. M. and Shim, J. P. (1995) 'An empirical investigation into DSS structures and environments', *Decision Support Systems*, 13(2), 141-158.

- Pioneer Valley Sustainability Network (2009) *Sustainability Decision Tool* [online], available: http://www.pvsustain.org/2009/07/sustainability-decision-tool/ [accessed 03 Apr 2019].

- Post, R. C. (1997) *Community and the First Amendment* [online], Faculty Scholarship Series. Paper 196., available: http://digitalcommons.law.yale.edu/fss_papers/196 [accessed 13 Mar 2017].

- Power, D. (2017) *What is a Spread-Sheet Based DSS?* [online], available: http://www.dssresources.com/faq/index.php?action=artikel&id=56 [accessed 16 Mar 2019].

- Power, D. (2018) *What software tools should be used to build web-based DSS?* [online], available: http://dssresources.com/faq/index.php?action=artikel&id=129 [accessed 31 Jan 2019].

- Power, D. J. (2016) *Are computerized decision aids decision support systems?* [online], available: http://dssresources.com/faq/index.php?action=artikel&id=120 [accessed 23 Nov 2018].

- Power, D. J. and Kaparthi, S. (2001) 'Building Web-based Decision Support Systems ', *Studies in Informatic and Control*, 11(4), 291-302.

- Pruitt, J. (2006) *The persona lifecycle keeping people in mind throughout product design*, Amsterdam: Morgan Kaufmann.

- Raghupathy, A., Emanuele Di, A., Dorairaj, P. and Oscar, H. F. (2013) 'Development and validation of a clinical and computerised decision support system for management of hypertension (DSS-HTN) at a primary health care (PHC) setting', *PLoS ONE*, 8(11), 1-11.

- Rahmel, D. (2009) 'Introduction to Joomla!' in *Beginning Joomla!*, Berkeley, CA: Apress, 1-9.

- Ramcilovic-Suominen, S. and PüLzl, H. (2018) 'Sustainable development – A 'selling point' of the emerging EU bioeconomy policy framework?', *Journal of Cleaner Production*, 172, 4170-4180.

- Rauch, F. (2002) 'The Potential of Education for Sustainable Development for Reform in Schools', *Environmental Education Research*, 8(1), 43-51.

- Ray, A. and Ramesh, D. (2016) 'Creation of a content management system using Drupal at Library, S'O'A University (Deemed), Bhubaneswar', *International Journal of Information Dissemination and Technology*, 6(3), 151-158.

- Redish, J. (2012) *Letting go of the words*, 2nd ed., Amsterdam: Morgan Kaufmann.

- Rizzoli, A. E. and Young, W. J. (1997) 'Delivering environmental decision support systems: software tools and techniques', *Environmental Modelling & Software*, 12(2), 237-249.

- Rogers, J. C., Simmons, E. A., Convery, I. and Weatherall, A. (2008) 'Public perceptions of opportunities for community-based renewable energy projects', *Energy Policy*, 36(11), 4217-4226.

- Romero-Rubio, C. and de Andrés Díaz, J. R. (2015) 'Sustainable energy communities: a study contrasting Spain and Germany', *Energy Policy*, 85, 397-409.

- Rose, D. C., Sutherland, W. J., Parker, C., Lobley, M., Winter, M., Morris, C., Twining, S., Ffoulkes, C., Amano, T. and Dicks, L. V. (2016) 'Decision support tools for agriculture: Towards effective design and delivery ', *Agricultural Systems*, 149, 165-174.

- Ross, A. (2018) 'The evolution of sustainable development in Scotland-A case study of community right-to-buy law and policy 2003-2018', *Sustainability (Switzerland)*, 11(1), 1-18.

- Rosson, M. B. and Carroll, J. M. (2002) *Usability engineering: scenario-based development of human–computer interaction* San Francisco: Morgan Kaufmann Publishers.

- Sandell, K., Ohman, J. and Leif, O. (2005) *Education for Sustainable Development: Nature, School and Democracy* Lund: Studentlitteratur AB.

- Scannell, Y. (2011) 'Renewable Energy Policies, Programmes and Progress in Ireland', *Journal of Energy & Natural Resources Law*, 29(2), 155-176.

- Schmidt, A. (2011) 'Save the Time of the Reader', *Library Journal*, 136(16), 20-22.

- Schuler, S. (1996) *New community networks: wired for change*, New York: ACM Press/Addison-Wesley Publishing Co.

- Schwartz, N. (2013) 'Craft a Tagline That Moves People to Take Action', *Computers in Libraries*, 33(8), 26-27.

- Sefelin, R., Tscheligi, M. and Giller, V. (2003) 'Paper prototyping - what is it good for?: a comparison of paper- and computer-based low-fidelity prototyping ', in *Conference on Human Factors in Computing Systems*, Ft. Lauderdale, Florida, USA, 5- 10 Apr, New York: ACM, 778-779.

- Seref, M. M. H. and Ahuja, R. K. (2008) 'Spreadsheet Based Decision Support Systems ' in Burstein, F. and Holsapple, C., eds., *Handbook on Decision Support Systems 1 Basic Themes*, Berlin: Springer Berlin Heidelberg, 277-298.

- Seref, M. M. H., Ahuja, R. K. and Winston, W. L. (2011) *Developing spreadsheet-based decision support systems* 2nd ed., Belemont, Mass Dynamic Ideas.

- Seyfang, G. (2009) *The New Economics of Sustainable Consumption: Seeds of Change*, Basingstoke, England: Palgrave Macmillan.

- Seyfang, G. (2010) 'Community action for sustainable housing: Building a low-carbon future', *Energy Policy*, 38(12), 7624-7633.

- Seyfang, G. and Haxeltine, A. (2012) 'Growing grassroots innovations: Exploring the role of community-based initiatives in governing sustainable energy transitions', *Environment and Planning C: Government and Policy*, 30(3), 381-400.

- Seyfang, G., Haxeltine, A., Hargreaves, T. and Longhurst, N. (2010) 'Energy and communities in transition–towards a new research agenda on agency and civil society in sustainability transitions', *Working Paper - Centre for Social and Economic Research on the Global Environment*, 1, 1-21.

- Seyfang, G. and Longhurst, N. (2013) 'Desperately seeking niches: Grassroots innovations and niche development in the community currency field', *Global Environmental Change*, 23(5), 881-891.

- Seyfang, G. and Smith, A. (2007) 'Grassroots innovations for sustainable development: Towards a new research and policy agenda', *Environmental Politics*, 16(4), 584-603.

- Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R. and Carlsson, C. (2002) 'Past, present and future of decision support technology', *Decision Support Systems*, 33(2), 111-126.

- Shoup, J. A., Wagner, N. M., Kraus, C. R., Narwaney, K. J., Goddard, K. S. and Glanz, J. M. (2015) 'Development of an Interactive Social Media Tool for Parents With Concerns About Vaccines', *Health Education & Behavior*, 42(3), 302-312.

- Sieber, S., Amjath-Babu, T. S., McIntosh, B. S., Tscherning, K., Müller, K., Helming, K., Pohle, D., Fricke, K., Verweij, P., Pacini, C., Jansson, T. and Gomez y Paloma, S. (2013) 'Evaluating the characteristics of a non-standardised Model Requirements Analysis (MRA) for the development of policy impact assessment tools', *Environmental Modelling and Software*, 49, 53-63.

- Simon, H. A. (1977) *The New Science of Management Decision* Revised ed., Englewood Cliffs, New Jersey: Prentice Hall.

- Simonovic, S. I. (1996) 'Decision Support Systems for Sustainable Management of Water Resources: 1. General Principles', *Water International*, 21(4), 223-232.

- Simpson, D. L. (2005) 'Content for one: developing a personal content management system', in *Proceedings of the 33rd annual ACM SIGUCCS conference on User services*, Monterey, CA, USA, 1099512: ACM, 338-342.

- Sinakou, E., Boeve-de Pauw, J., Goossens, M. and Van Petegem, P. (2018) 'Academics in the field of Education for Sustainable Development: Their conceptions of sustainable development', *Journal of Cleaner Production*, 184, 321-332.

- Skov, M. B. and Stage, J. (2012) 'Training Software Developers and Designers to Conduct Usability Evaluations', *Behaviour & Information Technology*, 31(4), 425-435.

- Smith, A. (2007) 'Translating Sustainabilities between Green Niches and Socio-Technical Regimes', *Technology Analysis & Strategic Management*, 19(4), 427-450.

- Smith, A. (2011) 'Civil society in sustainable energy transitions' in Verbong, G. and Loorbach, D., eds., *Governing the Energy Transition. Reality, Illusion or Necessity*, New York: Routledge, 180-202.

- Sorvari, J. and Seppälä, J. (2010) 'A decision support tool to prioritize risk management options for contaminated sites', *Science of The Total Environment*, 408(8), 1786-1799.

- Spark Change (2018) *Spark Change* [online], available: https://www.sparkchange.ie/ [accessed 25 Mar 2019].

- Spiegle, G., Al-Sukhni, E., Schmocker, S., Gagliardi, A. R., Victor, J. C., Baxter, N. N. and Kennedy, E. D. (2013) 'Patient decision aids for cancer treatment', *Cancer*, 119(1), 189-200.

- Sprague, R. H. (1980) 'A framework for the development of decision support systems ', *Management Information Systems Quarterly*, 4(1), 1-26.

- Sprague, R. H. (1982) *Building effective decision support systems*, Englewood Cliffs, New Jersey: Prentice-Hall.

- Suduc, A. M., Bizoi, M., Cioca, M. and Filip, F. G. (2010) 'Evolution of Decision Support Systems Research Field in Numbers', *Informatica Economica Journal*, 14(4), 78-86.

- Sustainable Communities Toolkit (2018) *Sustainable Communities Toolkit* [online], available: https://www.sustainabletoolkit.ie/ [accessed 25 Mar 2019].

- Tan, J., Linos, E., Sendelweck, M. A., Zuuren, E. J., Ersser, S., Dellavalle, R. P. and Williams, H. (2016) 'Shared decision making and patient decision aids in dermatology', *British Journal of Dermatology*, 175(5), 1045-1048.

- Tatnall, A. and Burgess, S. (2007) 'Experiences in Building and Using Decision Support Systems in Postgraduate University Courses ', *Interdisciplinary Journal of Information, Knowledge and Management*, 2, 33-42.

- Taylor Aiken, G. (2015) '(Local-) community for global challenges: carbon conversations, transition towns and governmental elisions', *Local Environment*, 20(7), 764-781.

- The Wheel (2019) *The Wheel* [online], available: https://www.wheel.ie/ [accessed 25 Mar 2019].

- The World Bank (2016) *The CURB Tool: Climate Action for Urban Sustainability* [online], available: http://www.worldbank.org/en/topic/urbandevelopment/brief/the-curb-tool-climate-action-for-urban-sustainability [accessed 25 Mar 2019].

- Thurow, S. and Musica, N. (2009) *When Search Meets Web Usability*, Indianapolis, IN: New Riders.

- Tomlinson, T. (2010) 'Introduction to Drupal' in *Beginning Drupal 7*, Berkeley, CA: Apress, 1-8.

- Tonelli, F., Evans, S. and Taticchi, P. (2013) 'Industrial Sustainability: challenges, perspectives, actions', *International Journal of Business Innovation Research*
- 7(2), 143-163.

- UN (2015a) *Adoption of the Paris Agreement* 21st Conference of the Parties, Paris: http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf [accessed 22 Mar 2019].

- UN (2015b) *Transforming our World: The 2030 Agenda for Sustainable Development A/RES/70/1* General Assembly, New York: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf [accessed 20 Mar 2019].

- Urry, J. (2009) 'Sociology and climate change', *Sociological Review*, 57(Suppl.2), 84-100.

- Vecchione, A., Brown, D., Allen, E. and Baschnagel, A. (2016) 'Tracking User Behavior with Google Analytics Events on an Academic Library Web Site', *Journal of Web Librarianship*, 10(3), 161-175.

- VOiCE (2019) *VOiCE* [online], available: http://www.voicescotland.org.uk/voice/ [accessed 25 Mar 2019].

- W3Techs (2019) *W3Techs - World Wide Web Technology Surveys* [online], available: https://w3techs.com/ [accessed 18 March].

- Walker, G. (2008) 'What are the barriers and incentives for community-owned means of energy production and use?', *Energy Policy*, 36(12), 4401-4405.

- Walker, G. (2011) 'The role for 'community' in carbon governance', *Wiley Interdisciplinary Reviews: Climate Change*, 2(5), 777-782.

- WCED (1987) *Our Common Future: a Report from the United Nations World Commission on Environment and Development* Oxford: http://www.un-documents.net/our-common-future.pdf [accessed 30/08/18].

- Webb, G. K. (2011) 'Designing and Building a Knowledge Warehouse Oriented, Public Decision Support Site Using Free Google Tools: An Analysis and Case Application to Deer Management', *Issues in Information Systems*, 12(1), 280-290.

- West, J. (2016) 'Tools for Writing for the Web', *Computers in Libraries*, 36(3), 12-14.

- Wheel (2019) *Upcoming Traning and Events* [online], available: https://www.wheel.ie/training [accessed 23 Mar 2019].

- White, C. and Raman, N. (1999) 'The World Wide Web as a public relations medium: the use of research, planning, and evaluation in web site development', *Public Relations Review*, 25(4), 405-419.

- Whitson, L. (2012) 'Five Tips for Choosing the Right Domain Name', *International Musician*, 110(4), 10.

- Wiegers, K. E. (1999) 'Software process improvement in Web time', *IEEE Software*, 16(4), 78-86.

- Williams, D. and Kennedy, M. (1999) 'Towards a Model of Decision-Making for Systems Requirements Engineering Process Management', in *International System Dynamics*, Bergan, Norway, 6-10 Aug, 1-14.

- Yin, R. K. (2009) *Case study research : design and methods*, 4th ed., Los Angeles: SAGE.

- Zainuddin, F. B. and Liu, S. (2011) 'Integrating prototyping into the SOFL three-step modeling approach', in *International Conference on Formal Engineering Methods*, Durham, United Kingdom, 163-178.

- ZECOS (2015) *Zero CO2e emission certification system evaluation report WP4 A19* Internal Report, unpublished.

- Zeng, G.-m., Qin, X.-s., Wang, W., Huang, G.-h., Li, J.-b. and Statzner, B. (2003) 'Water environmental planning considering the influence of non-linear characteristics', *Journal of Environmental Sciences*, 15(6), 800-807.

- Zhang, B. and Carter, J. (2018) 'FORAGE – An online system for generating and delivering property-scale decision support information for grazing land and environmental management', *Computers and Electronics in Agriculture*, 150, 302-311.

- Zhao, X., Bai, S. and Zhang, X. (2019) 'Establishing a decision-support system for eco-design of biological wastewater treatment: A case study of bioaugmented constructed wetland', *Bioresource Technology*, 274, 425-429.

- Zulkafli, Z., Perez, K., Vitolo, C., Buytaert, W., Karpouzoglou, T., Dewulf, A., De Bièvre, B., Clark, J., Hannah, D. M. and Shaheed, S. (2017) 'User-driven design of decision support systems for polycentric environmental resources management', *Environmental Modelling & Software*, 88, 58-73.