Kelp & Climate Migration:

Fig.1 : Kelp Forest

Fig.2 : Climate Migration

the importance of the integral complexity within the systems, what is driving the issues facing them & what can be done to help

I will explore systems of kelp forests alongside climate migration, investigating the two complex systems and the interdisciplinary and multifaceted problems facing them. Focusing on both natural and anthropogenic factors in order to provide better insight into both systems and the vast array of social, economic, technological and environmental implications which they hold.

Explaining and defining the complex systems, the problems facing them and what makes them complex. Then looking into contemporary and interdisciplinary research on the systems through their relationships with Complexity, Collective Intelligence, Artificial Intelligence (AI), Design Thinking, Healthcare and Economics.

'Kelp forests are highly complex ecosystems found in temperate to cold shallow oceans and seas, they consist of a variety of large and often densely packed macroalgae – this large brown/green subspecies of seaweed support many marine, costal, eco, financial and aquacultural systems.' [1] They have massive effects on their local and wider environments and ecosystems; however, they also have large impacts on societies, particularly coastal communities. I will investigate what may advance and what is currently preventing the protection and sustainable management of these systems.

Climate migration is a complex social system which is directly affected by the environment

and climate change, it consists of the movement of people, communities and societies from regions which may have been ancestorial or generational homes due to a lack of opportunity, resources, space or habitability instigated by the effects of climate change. "Climate change, [is an] an increasingly potent driver of migration, continu[ingle to compel millions of people to leave their homes every year",[2] the severity of which continues to increase with the effects of climate change worsened by resistance to adapt living systems.

Both highly complex systems have obvious differences, one being a social phenomena and the other being an ecosystem, however there are also many factors and concepts which bring the two systems together. I will look to provide a systemic insight to the interdisciplinary synthesis, cultural, social, cognitive and behavioural implications and systems within both kelp forests and climate migration.

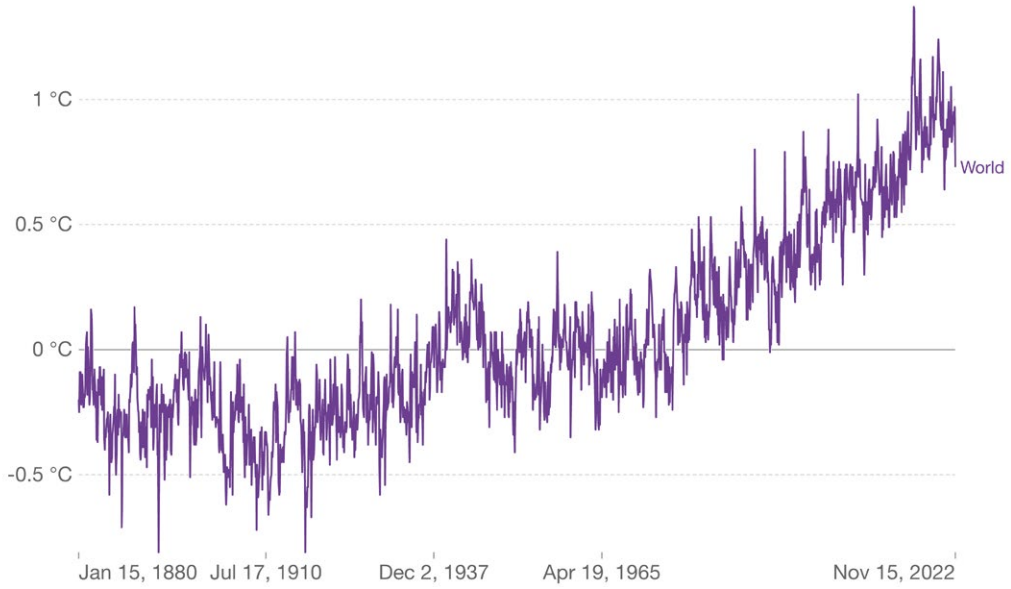


Fig.3 : This diagram shows how monthly global land and sea, monthly surface level temperature anomolies - directly leading to the detriment of kelp forest systems and the increase of forced climate migration

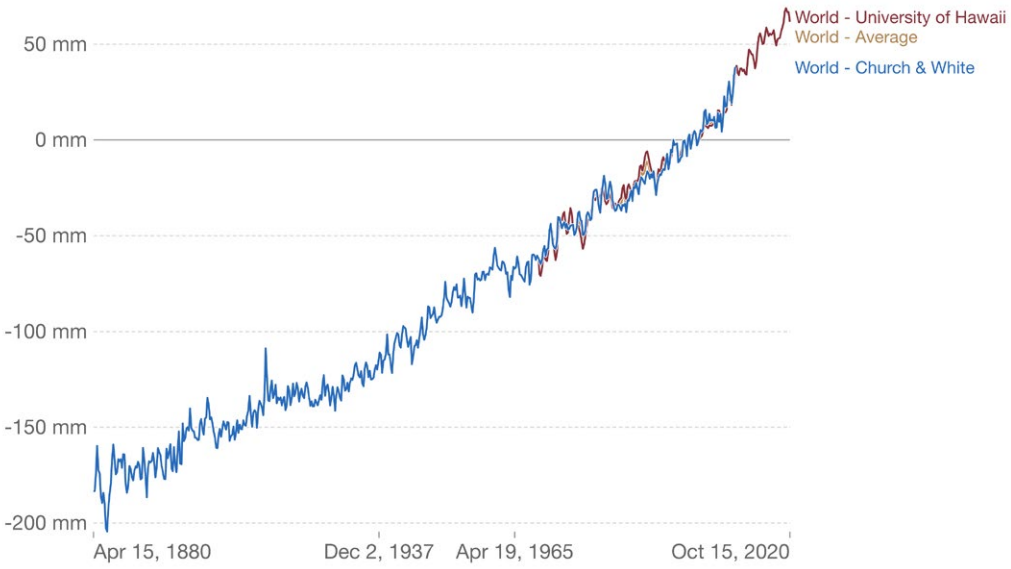


Fig.4 : This diagram shows how sea level rise based on the Church-White dataset, University of Hawaii Sea Level Centre data, and the average of the two - it directly leads to both kelp forest decline and climate migration

I will examine the systems using approaches such as the 'macro-sociological perspective that seek to explain the dynamics of the "capitalist world economy" as a "total social system"' [3] described in world systems theory. As well as humanities tendency to 'sacrifice' areas which are deemed out of their control or too difficult to repair, detailed in 'sacrifice theory' such as in coastal areas off Chile where "sacrificial zones, have created significant anoxic zones and metal contamination, as well as air pollution from processing that affect coastal towns" [4] causing significant detriment to kelp forests and the communities relying on them. Similarly in lower income regions "Social, environmental and health costs of such industrialization, [however], bear on low-income communities inhabiting severely degraded territories by polluting activities." [5] Which exacerbate efforts in the region to reduce climate migration.

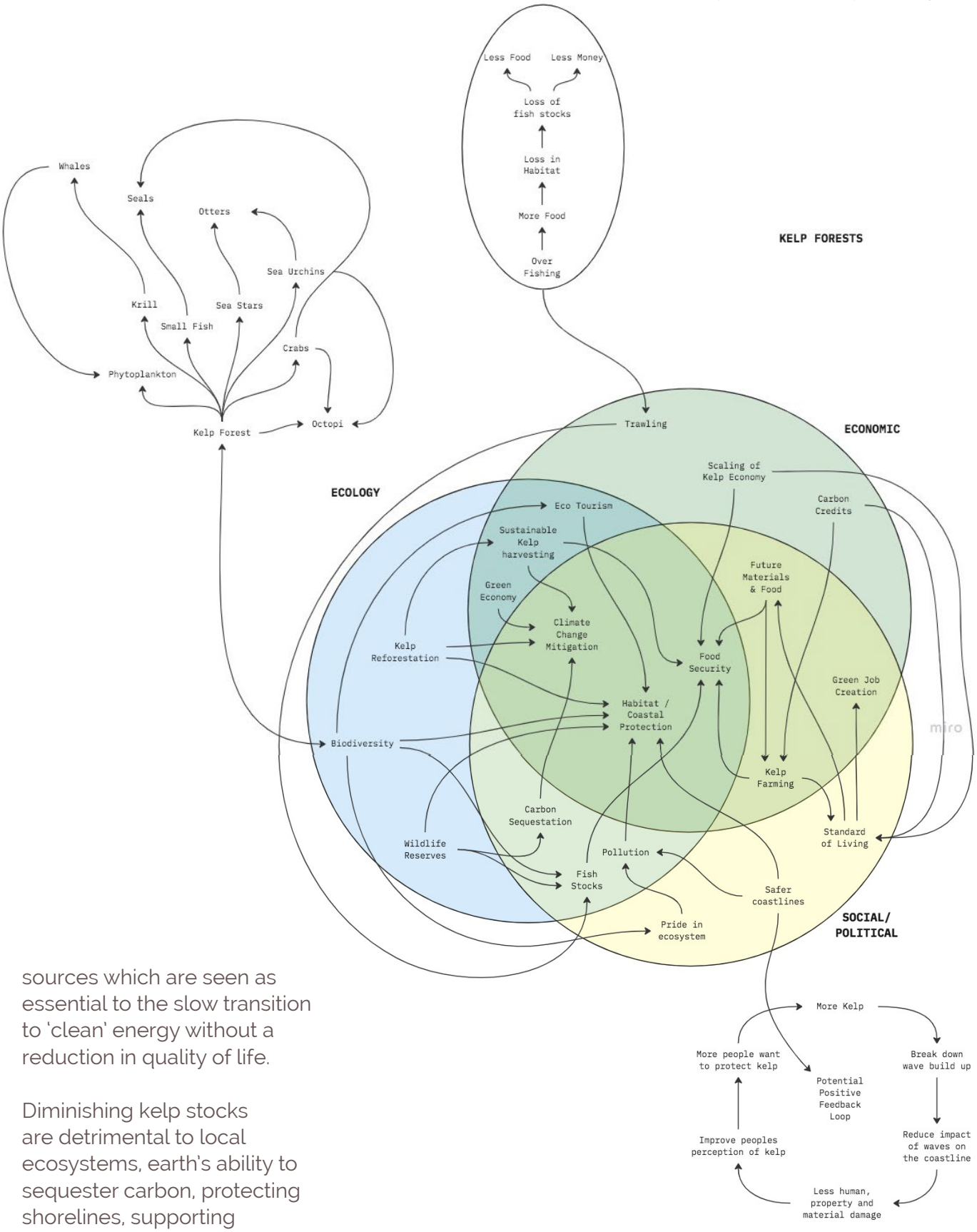
There are many elements which make Kelp forests complex, the inter-reliant nature of the immense amount of life which they host, their scalable near fractal form, their interaction with society and their relationship with their local and wider environments. They are non-linear and unpredictable systems within which tiny alterations could be made which result in huge effects across the system.

There are several large problems facing kelp forests, anthropogenic issues such as overharvesting, overfishing, pollution and habitat destruction as well as 'natural' causes such as rising sea temperatures, ocean acidification, sea level rise and invasive species. However, most of these 'natural' causes are caused or at least catalysed by climate change, so are also indirectly anthropogenic.

Over-fishing and harvesting have become common practice in many communities, while other issues such as pollution and anthropogenic CO2e emissions are difficult to cut down due to "Accelerating economic globalisation - means certain countries, such as Chile, Brazil, China, the Arabian Gulf and India among others, are experiencing significant coastal pollution from rapid industrialisation" [6] as well as continued use of carbon intensive energy

Fig.5 : This diagram shows an example of a sacrifice zone

Fig.6 : Diagram showing some of the complexities within Kelp Forest Systems



sources which are seen as essential to the slow transition to 'clean' energy without a reduction in quality of life.

Diminishing kelp stocks are detrimental to local ecosystems, earth's ability to sequester carbon, protecting shorelines, supporting coastal communities, healthy, economically and environmentally beneficial food and to future industries looking into compostable, sustainable and fast-growing materials.[7]

Climate migration and inequalities within it are inherently complex due to the vast number of variable factors and the immense range of scale of the problem, from displacing individuals to entire countries.

Increased severity and frequency of an issue such as flooding may cause individuals to leave an area. While the Maldives are potentially looking to purchase foreign land in order to relocate their entire population, government and culture, creating the possibility of an entire country's population becoming climate migrants as "Eighty percent of the country's 1,200 islands - [which] are less than one metre above sea level, - [to] be submerged within 100 years." [8] The system is so complex due to the combination of highly unpredictable and chaotic systems in climate change, weather systems and human decision, built upon phenomena such as the Durkheim dilemma,[9] stating people as a group may make significantly different decisions than they may make as individuals.

The main cause of climate migration is the environmental and physical impacts brought about by climate change, such as rising sea levels, increasingly extreme weather patterns, particularly severity of drought and desertification - making large areas of previously fertile land increasingly hostile. These physical factors paired with a myriad of social complexities such as a lack of preparedness and policy, as well as socio-economic and political stressors slow down mitigation tactics and can create scenarios where people are less able to cope with increasingly hostile conditions.

Climate migration leads to loss of culture, community and local knowledge. While scarcity in rural areas pushes people to urban areas causing issues such as 'overurbanisation'[10] climate migration in conjunction with the effects of post-colonialism can push the most highly skilled and educated people to areas of the global North and 'West' as 'natural disasters due to climate change exacerbate the brain drain in developing countries characterized by the migration of highly skilled people just when those countries are at their most vulnerable and need greater support from skilled workers to deal with the damage associated with natural disasters.' [11]

Looking to resolve either of the problems faced by these two complex problems will take complexity and interdisciplinary thinking, requiring integration of expertise from a broad range of fields such as economics, (marine) biology, policy, sociology, aquaculture, climate science, conservationism, anthropology, urban/infrastructure design and many more. As well as willingness and cooperation of a wide range of stakeholders from local communities to scientists and local, regional, national and international governmental bodies. This vast array of stakeholders and the immense complexity of these issues forces any solutions to be equally complex and interdisciplinary.

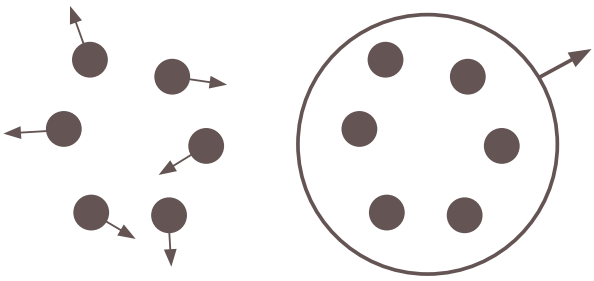


Fig.7 : Diagram depicting the effects of the Durkheim Dilemma

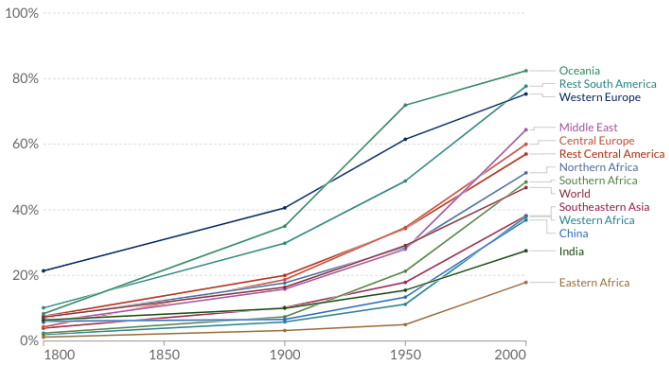


Fig.8 : Diagram showing rate of urbanisation in developing world

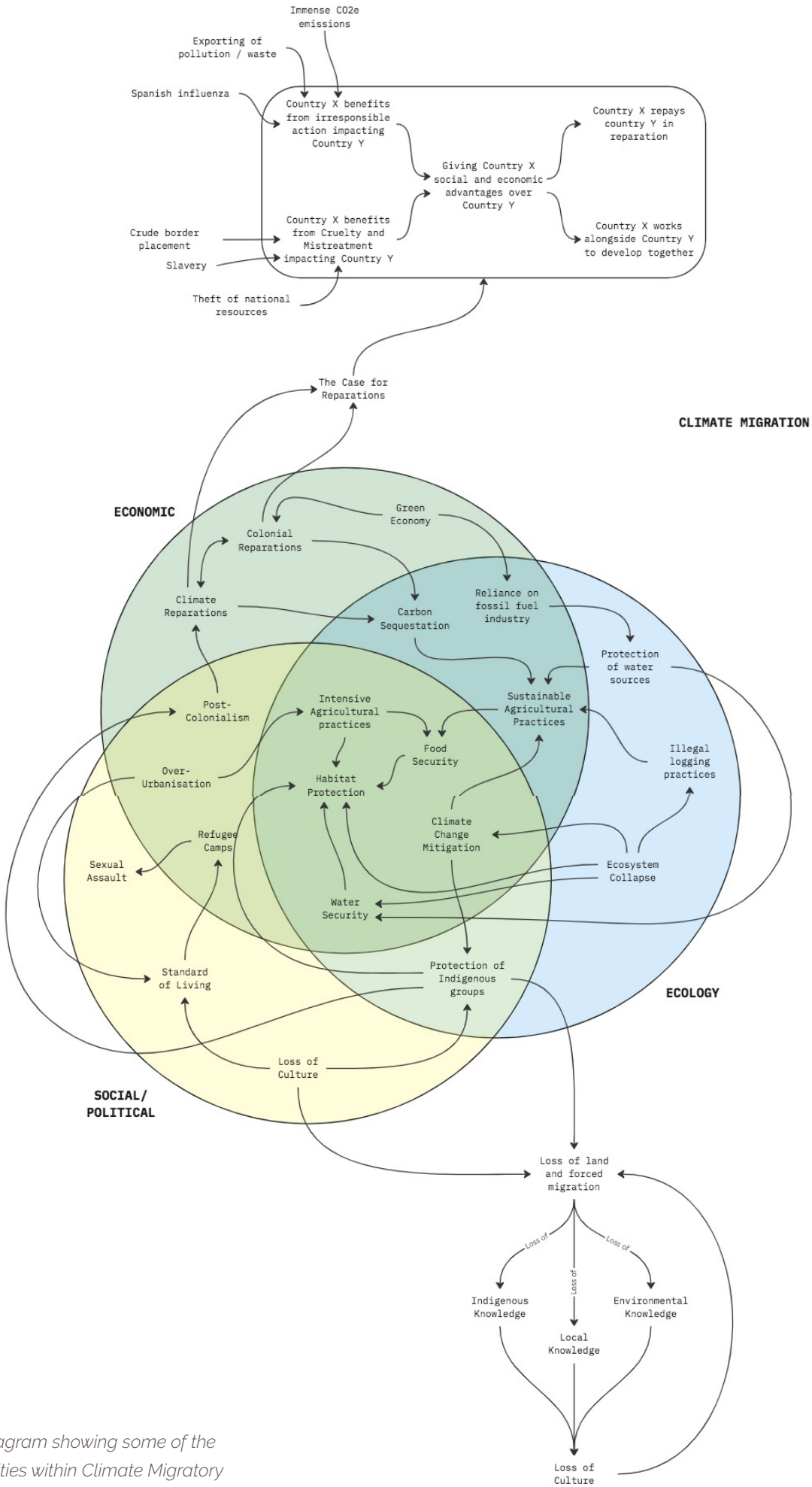


Fig.9 : Diagram showing some of the complexities within Climate Migratory Systems

Artificial Intelligence has and will have many wide-ranging impacts in our lives, the technology is growing extremely quickly, despite controversy largely around the current difficulty in regulation. This difficulty creates and exacerbates existing inequality, economic disruption / unemployment, as well as ethical and moral issues such as accountability. However, with time and regulation it has the capability to become an incredibly powerful tool to assist in facing issues in both kelp forest and climate migratory systems.

Most benefits come through AI's immense ability to gather, organise and analyse large amounts of data, which can lead to better prediction and modelling of complex systems. In the context of kelp forests and climate migration, AI can help to better collect and analyse data leading to better mapping and predictions, leading to more effective intervention in both systems whether it is more effective conservationism in kelp forests or determining areas at most risk of increasingly hostile conditions and climate migration. Another advantage is the ability to develop education and communication, providing deeper insight/understanding to a wide range of people, enabling more effective action.

AI can help monitor and map kelp forest systems, helping scientists measure the systems' changes and health. It is also very good at discovering patterns in this data, increasing effectiveness of restoration and preservation efforts. AI can also help kelp forests through accurately measuring CO2e sequestration, a famously difficult task, and one which becomes increasingly difficult when it is in the sea, a Norwegian study done in Australia estimated that kelp forests accounted for around '30% of the total blue carbon sequestered annually' [12] by the nation. AI could help kelp forests become a huge carbon credit market if the accurate measurement of their CO2e sequestration allows financial compensation for governments and individuals to protect or grow kelp.

In the context of Climate Migration, AI could prove extremely useful in dealing with disaster response and resource allocation, enabling governments and other bodies to better deal with the aftermath of climate disasters. Its ability to gather huge data sets on natural resources and changing weather patterns allows models to predict areas at most risk, increasing action before disaster. AI can also help enact the strategies of which it helps inform, helping to design better urban preparedness, infrastructure or mitigation systems.

While AI has the potential to mitigate and prevent the worst effects in both systems, it also has the potential to be used by governments and companies to expand mining, fossil fuel drilling, monoculture farming and the over extraction of resources such as kelp or other keystone species, leading to further degradation of kelp forest systems and the increase in forced climate migration. The technology can also be prone to bias and discrimination, allowing some to use it to their advantage while others who may adapt to technology less quickly are negatively impacted by it. Finally, it can be used to great effect to influence and radicalise the public, most notably it's use in elections,[13] creating political uncertainty (which unlike risk cannot be measured or predicted), making it hard to ensure protection of natural resources (kelp forests) or help for those facing climate migration.

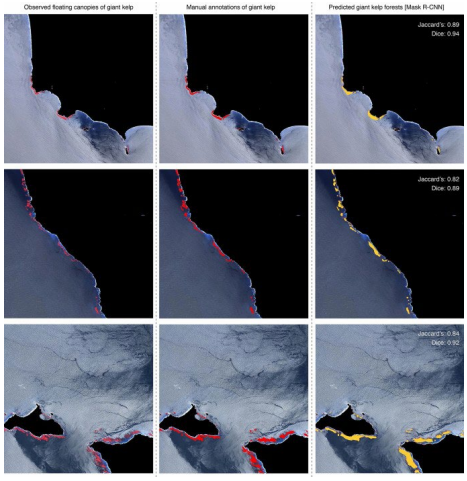


Fig.10 : AI generated maps showing kelp forest health

Design thinking 'is a human-centered approach to innovation—anchored in understanding customer's needs, rapid prototyping, and generating creative ideas' [14] the approach is more wholistic than other approaches, looking past what people sometimes consider more traditionally as 'design'.

It hosts a range of benefits for kelp forest and climate migratory systems. It allows for creative and wide-ranging ideas which come through prototyping many different options. Helping people look at designing systems and frameworks which allow collaboration, whether alongside or in the future. Design thinking can also greatly contribute to education on both systems, helping create a system for change and looking to utilise ideas such as innovation diffusion.

Kelp forest systems would benefit from design thinking methods as it would allow a fresh stream of innovation and ideas into the effort of conservation. There are many under-explored ways to benefit from the protection of kelp forests, which design thinking would help to realise. Such as the use of carbon credits to ensure the retention of the carbon sequestering ecosystem. It could also help to investigate other solutions such as education, eco-tourism and how allowing them to protect shorelines and regenerate fish stocks may be more economically effective than harvesting the kelp, accounting for associated costs of coastal defences or declining fish/ biodiversity stocks.

Climate migration would benefit from design thinking through the creation of innovative options to support those most affected by climate change. This could include design for new infrastructure, ways to support and work with displaced communities as well as looking into ways to better integrate those who have been displaced into society where they move to. It may investigate systems to help rural communities deal better with water scarcity through more efficient agriculture practises, ways to slow water from rainy seasons keeping it flowing through dry seasons for longer [15] or in the form of projects like 'Warka Water Towers' [16] which take a multidisciplinary approach to mitigating the effects of water scarcity, allowing communities to remain where they are.

Design thinking allows integration of diverse perspectives and innovative solutions, allowing for considerations of perspective, needs of the community and through the testing of ideas, it also allows for a large degree of collaboration and creativity due to the nature of iteration. Design thinking and educating people on it will allow a framework to continue current work, replacing the current system where NGOs, charities and governments operate in relative isolation. Despite this, design thinking is a time and resource intensive practice, it also has the potential to leave some stakeholders out of the process resulting in solutions which outwardly seem to work but are not adopted or supported by the community.

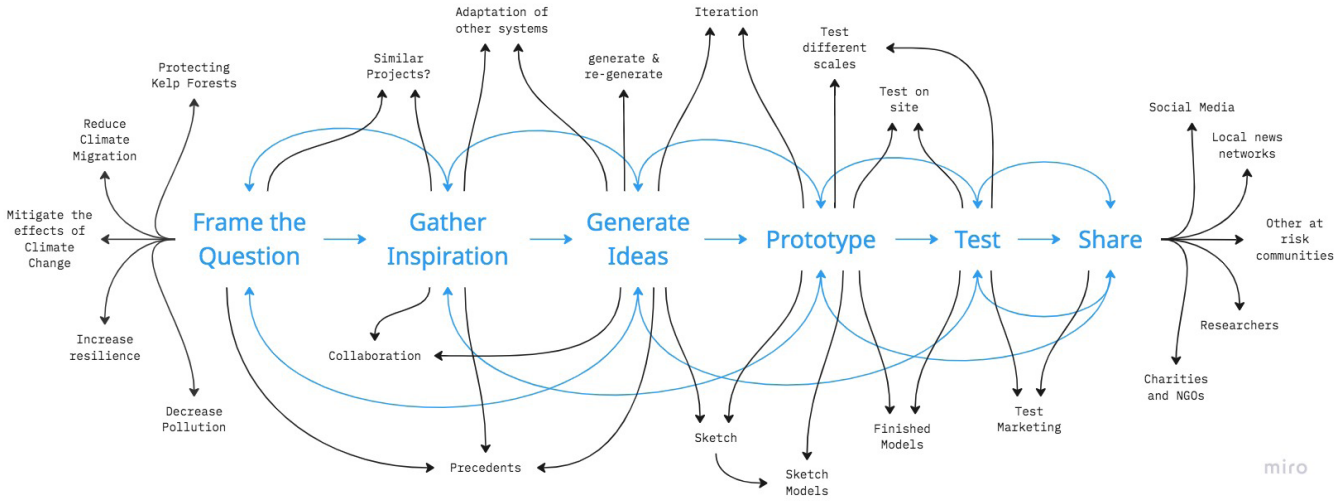


Fig.11 : Diagram showing some methods of Design Thinking applied to Kelp Forests and Climate Migration

Healthcare is a broad reaching field with implications surrounding inequality, climate migration, brain-drain and biodiverse ecosystems such as kelp forests. It is increasingly becoming inseparable from technologies such as AI and digital or mobile health.

The use of digital and mobile education in healthcare can be greatly beneficial to both climate migration and kelp forests. Educating people about health benefits of kelp forests can lead to increased protection and farming of these systems; in climate migration healthcare education is particularly important for marginalised or displaced populations. Using mobile health will enable millions of people to better understand regional difference in law, track disease, allow displaced people to keep in contact with their previous medical carers who understand their needs as well as other related complexities.

Healthcare and kelp forest systems are interrelated through the wide range of health benefits of consuming kelp, use in traditional medicine (potentially being an effective anti-inflammatory),[17] kelp forests' ability to create environmentally healthy systems; important as healthy kelp systems allow for an abundance of fish and other food sources, finally kelp forests also clean water and protect coastal areas from floods and storm surges which can lead to outbreaks of disease.[18]

Climate change, the driver behind climate migration increases frequency and spread of vector-borne disease through several means, becoming a direct cause of climate migration.[19] For example, 2019's Cyclone Idai had 'catastrophic outcomes in Malawi, Mozambique, and Zimbabwe — [and] set in motion a cycle of events affecting people's lives and further weakened the region's vulnerable health system' [20]

The displacement of people creates issues with traditional healthcare systems, advancing demand for digital/mobile healthcare which can allow displaced people to continue receiving medical aid. This is particularly important when large populations are displaced, or there is a language barrier.

Climate migration also creates adverse effects for the areas displaced people leave. Reducing populations can reduce resources and demand in affected areas, leading to the collapse of traditional healthcare systems.

Differences in policy and law can mean that people who expect or are used to receiving a certain treatment may be unable to receive the same treatment where they have moved to. This issue is particularly visible for abortion rights, a problem which is compounded by the high amount of sexual assault and rape in refugee and migrant populations.[21]

Mobile and digital health have potential to exclude those who need it most in the context of climate migration, as it is relatively inaccessible to those who do not have access or literacy in mobile or digital systems, providing the potential to then leave these people behind when advancements are rolled out. Studies have shown that people with low digital literacy, older people,[22] people of BAME backgrounds,[23] people from less financially stable backgrounds and people with SMIs[24] are far less likely to use or benefit from digital or mobile health. Climate migrants have a relatively high potential for many or all these issues to overlap, meaning that a high proportion will be in the demographic least likely to benefit from digital and mobile health techniques. However, they can still be useful tools if rolled out alongside physical / in person healthcare initiatives, and the technology is used by professionals and people working in healthcare, relying on innovation diffusion to expand eventual use to wider proportions of the affected populations.

Fig.12 : Remote healthcare in climate risk areas

Economic systems are highly complex and difficult to model or predict due to them not necessarily being in equilibrium, outlined in the theory of complexity economics, pioneered at the Santa Fe institute.[25] Complexity economics integrates into both kelp forest systems and climate migration, the problems facing them and the inequality within it. It can be used to think about and analyse both systems in a way which makes less assumptions than a neo-classical approach, essential due to the amount of complexity in both systems.

Many of the issues facing kelp forests systems can be solved through looking at economics, kelp forests contribute to local and wider economies through provision of food and medicine, regulating water quality, providing habitat for other marine animals and through protection of coastal areas from erosion, storms or floods. Kelp forests also provide employment through their harvesting, processing and distribution. There are also many innovations exhibiting further ways kelp forests can contribute to the economy, such as carbon credits or the use of kelp in textile and manufacturing industries.

The main economic impacts are focused in areas most affected by climate migration, including costs of human and social capital, disruption of communities and loss of local and traditional knowledge. There are also costs and benefits associated with areas where migrants have relocated to, such as the provision of shelter, resources, housing and healthcare as well as increased potential for social unrest.[26] Potentially offset by the fact that many populations rely upon the influx of young workers into their economies such as the UK or Japan, despite not necessarily treating them well when they are there.[27]

Using complexity economics to think about kelp forests and climate migration can improve the situation due to the methods' ability to identify key drivers and feedback loops, helping analyse the resilience of the natural and social systems in place. It can also lead to adaptation in areas at high risk of climate change, to adapt skills and in areas such as agri/aqua-culture; driving innovation and leading to more environmentally and economically sustainable practices. Complexity economic thinking can also anticipate nonlinear responses to external impacts such as anticipating effects of catastrophe theory or sudden and large changes in patterns whether they are ecological or social migratory patterns. Finally, complexity economics encourages the consideration of different stakeholders and can provide insight and inform policy, management and mitigation strategies.

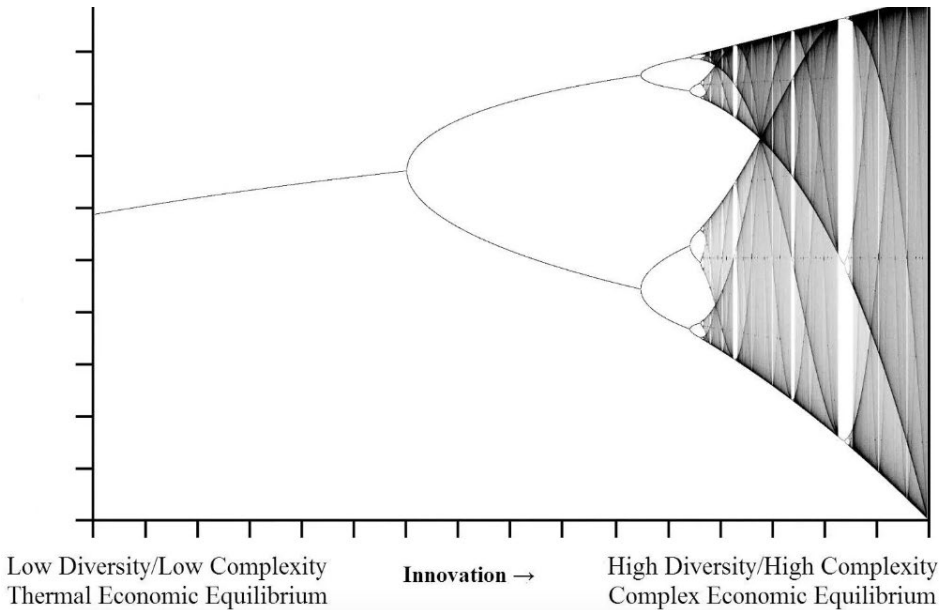
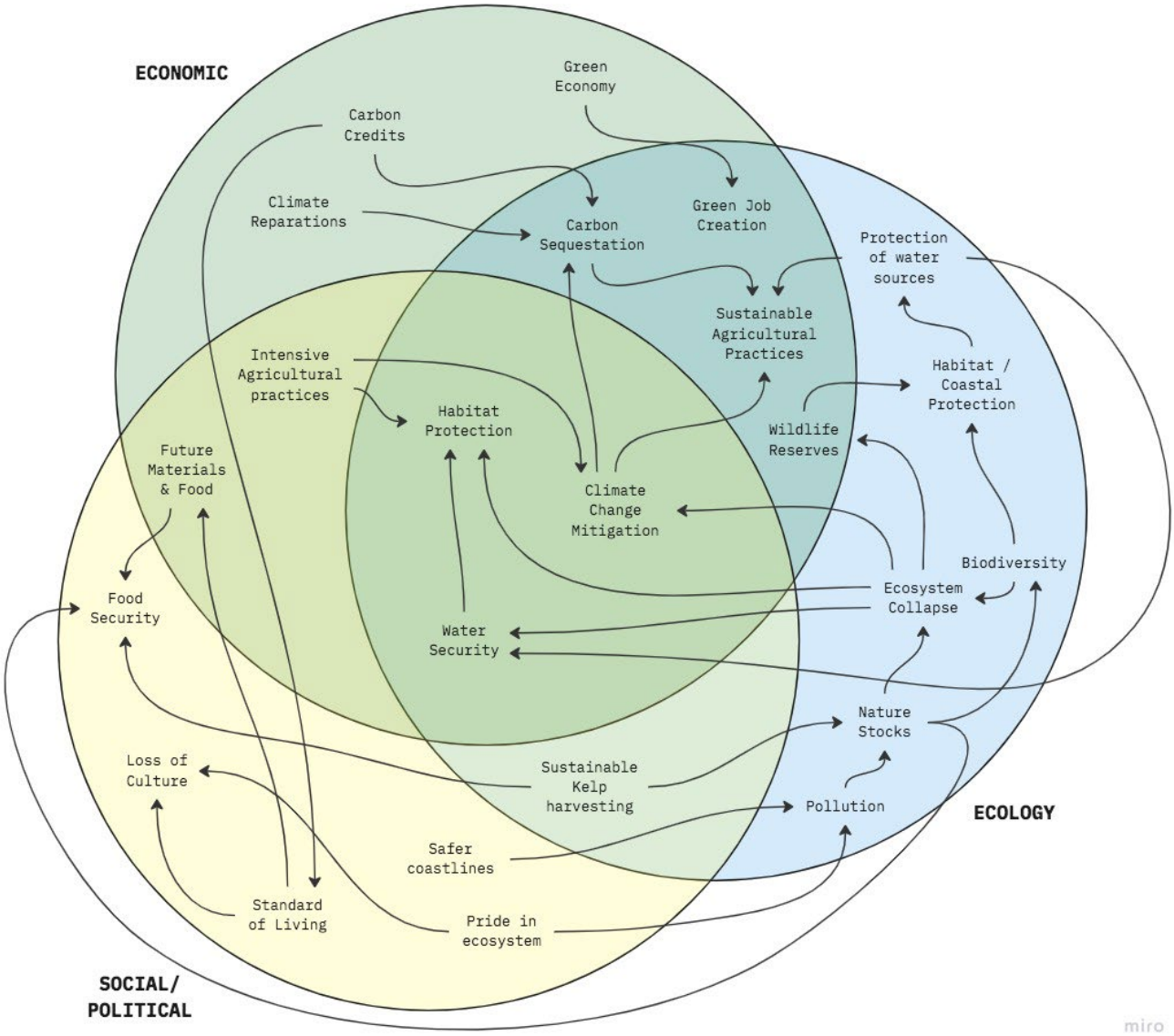


Fig.13 : Bifurcation diagram showing diffusion of equilibrium, outlining unpredictability of economic system

Fig.14 : Diagram combining overcrossing elements from the complex systems of Kelp Forests and Climate Migration



Collective Intelligence and intentionality in terms of kelp forest systems and climate migration refers to ways in which people and groups intend and come together, interact and solve problems related to the two systems through a combination of collaboration and communication.

Due to the wide range of people and parties involved collective intelligence and intentionality are essential in the preservation of kelp forests and the mitigation of climate migration. Essential in creating, developing and implementing policy and strategies which respond to the main issues facing kelp forests and climate migration. The methods

allow the development and implementation of management strategies which respond to the needs of all stakeholders, while addressing the root causes of climate migration, climate change.

Collective intelligence could be used in order to facilitate collaboration among stakeholders to help correct or mitigate the issues facing kelp forest systems and climate migration, bringing together scientists, resource managers, local and wider government officials and local communities in order to reduce the most detrimental effects on the systems without sacrificing local communities or sociality. For example, it would be bad practice to ban all harvesting of natural kelp forests as this would negatively impact rural communities who rely on this source of work, food and money – for whom kelp harvesting has become a part of their identity and culture.

There are many ways through collective intelligence and intentionality communities, cultures and societies can be protected as well as kelp forests. For example, communities could be subsidised not to over-harvest the kelp through paying them to retain some of the forest as carbon sinks, this may also encourage social mobility and green entrepreneurship through encouraging people to grow more kelp. Bans on large fishing companies which destroy fish and kelp stocks can also mean that smaller scale operations benefit from increased yields and better protected kelp forests, this again can improve social mobility for local community members.

Climate migration is inherently detrimental both to sociality and to community, by using cultural and social tools alongside collective intelligence, intentionality and engagement it is possible to improve issues associated with climate migration. Through bringing together experts and stakeholders from many disciplines to help communities and societies – designing systems to encourage shared resource allocation can be a good way to improve living standards in many areas, looking to influence large consumers of natural resources as a group can be beneficial, and encouraging farmers to use traditional methods which are often more water efficient or to change to less water intensive crops.

Cognitive and Behavioural tools can be used in junction with collective intelligence and intentionality to benefit both kelp forest and climate migratory systems. Primarily through the facilitation of communication, collaboration and decision making.

Kelp forest and climate migratory systems benefit directly from many cognitive and behavioural tools, particularly when used in junction with collective intelligence and intentionality. Some of the most useful of these tools are the creation of decision-making frameworks, allowing a wide range of groups to work together in the present and future to make collective decisions regarding the systems. Another way in which cognitive and behavioural tools can be utilised is through the creation of better collaboration and communication tools in order to facilitate the spread of information, which leads to better understanding of what each stakeholder wants, meaning others are better able to reach understanding, compromise and solutions which suit the most stakeholders.

More specific ways in which cognitive and behavioural tools can be used to help issues facing kelp forest and climate migration systems are outlined throughout the essay, some examples include the use of conscious and guilt to encourage carbon offsets or charitable donations, looking at digital and mobile learning techniques and looking at ways in which populations show complex and often unpredictable behaviours like those outlined in catastrophe theory or the Durkheim dilemma.

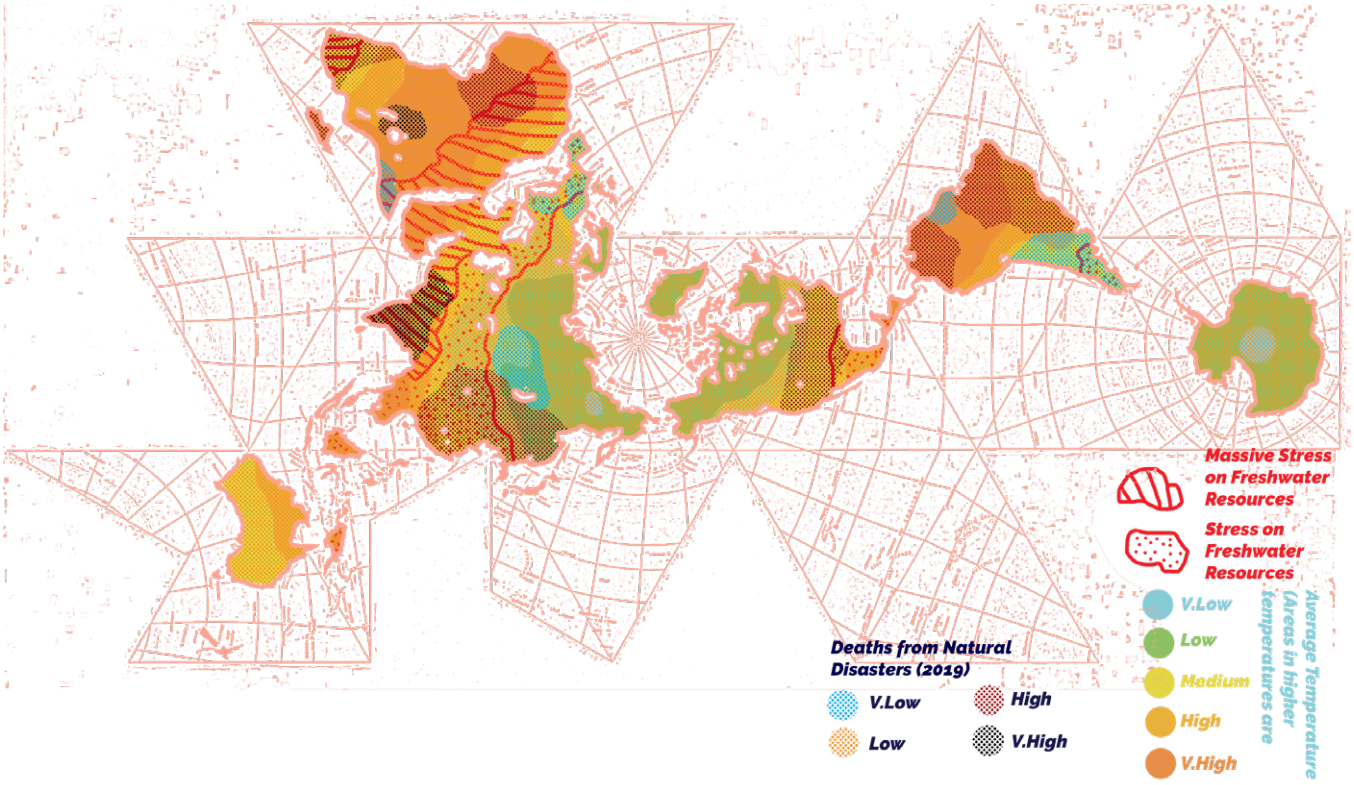


Fig.15 : Map showing physical risk of climate change, showing deaths from natural disasters, average temperature and the level of stress on freshwater sources

Climate migration and Kelp systems, for all their similarities are still inherently hugely different, one is a natural ecosystem which have existed for millennia, the other, a relatively contemporary social issue caused by changes in the natural environment. Proving this by interacting with interdisciplinary theories in diverse, complex and often different ways.

However, through the use of social, cultural, cognitive and behavioural tools I have found many ways in which the monumental environmental and social issue of climate migration and the complex problems facing kelp forests are alike – predominantly in their highly complex nature and their direct and negative relationship with climate change, both natural and anthropogenic, the over utilisation of natural resources whether that is water, land, kelp or sea animals as well as the required collaboration and synthesis of multiple fields in the approaches to solve or mitigate the worst effects in the systems. The systems showed multiple overlaps in their relations with AI, Healthcare, Design Thinking and Complexity Economics and in their interdependence on collective intelligence and intentionality.

Both systems show chaotic tendencies and are impossible to accurately predict, this makes reducing or preventing their related issues difficult, however this difficulty can be mitigated in a multitude of ways using the techniques, methods and technologies outlined above in conjunction with collective intelligence and intentionality. I have investigated recent innovations and contemporary research within the complex systems (AI's ability to better track CO2e sequestration in kelp forests and the application of complex healthcare systems in climate migration), as well as the complexity of the systems themselves.

Whether to gather more data on issues and create more accurate models or to investigate better ways to educate rural populations the only way to better understand the systems through the shrouding complexities surrounding them and attempt to mitigate or prevent increasingly adverse effects is through a wide interdisciplinary, collaborative, social and ecological lens.

[Work includes 3,993 words]

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Fig. 3 : Climate Change Impacts Data Explorer. (n.d.). Our World in Data. Retrieved January 8, 2023, from https://ourworldindata.org/explorers/climate-change?facet=none&Metric=Temperature+anomaly&Long-run+series%3F=false&country=OWID_WRL~ATA~Gulkana+Glacier~Lemon+Creek+Glacier~North+America~South+Cascade+Glacier~Wolverine+Glacier

Fig. 4 : Climate Change Impacts Data Explorer. (n.d.). Our World in Data. Retrieved January 8, 2023, from https://ourworldindata.org/explorers/climate-change?facet=none&Metric=Sea+level+rise&Long-run+series%3F=false&country=OWID_WRL~ATA~Gulkana+Glacier~Lemon+Creek+Glacier~North+America~South+Cascade+Glacier~Wolverine+Glacier

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Fig. 12 : The Climate Change, Migration, and Health (Care) Nexus: Implications for Low-income Regions. (n.d.). Our World. Retrieved January 13, 2023, from https://ourworld.unu.edu/en/the-climate-change-migration-and-healthcare-nexus-implications-for-low-income-regions

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