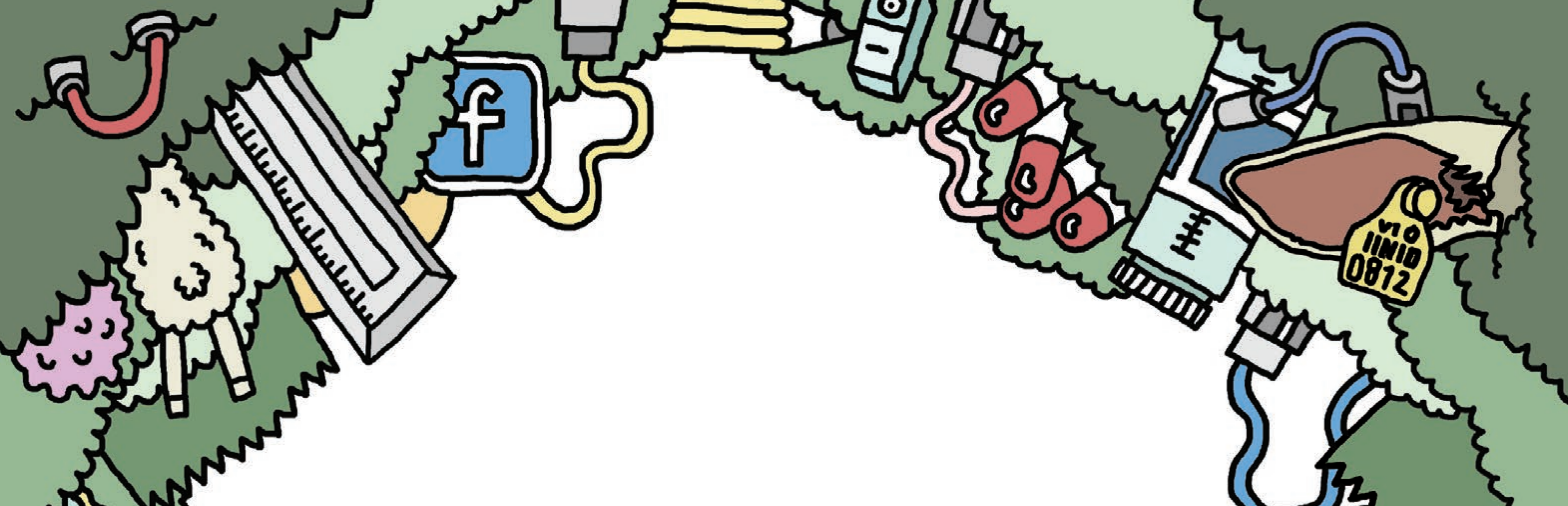
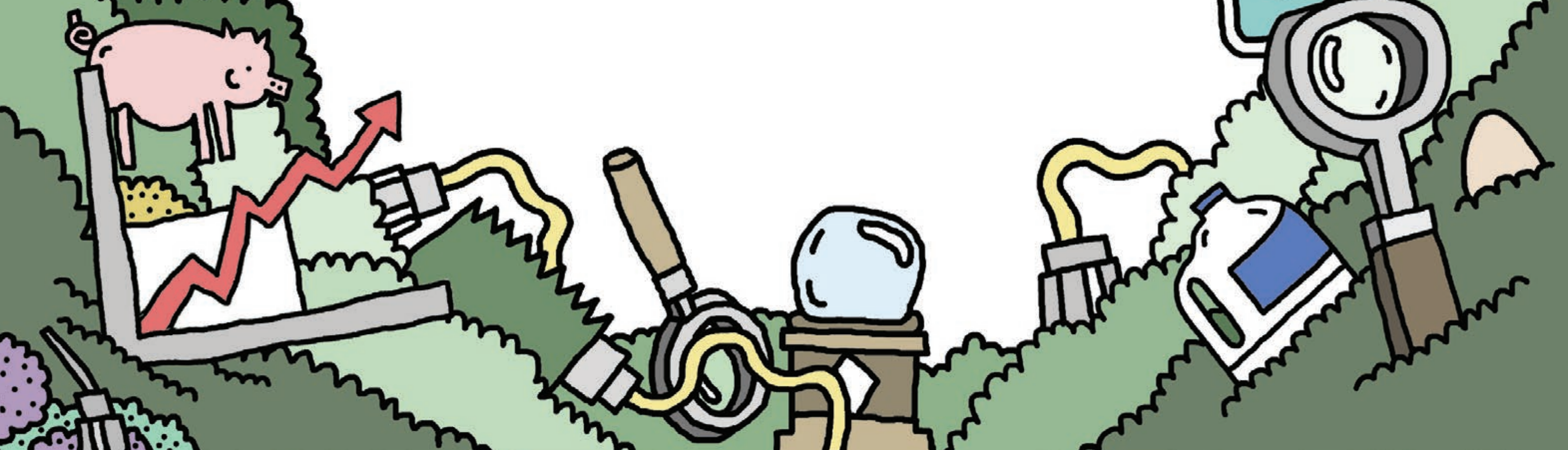


An EPIC Scenario Planning Workshop

Year 2030: What is the future of animal surveillance in Scotland?

epic
Centre of Expertise on Animal Disease Outbreaks



EPIC, Scotland's Centre of Expertise on Animal Disease Outbreaks has been established with the overarching purpose of providing expert advice on animal health and disease outbreaks to policymakers from the Animal Health and Welfare Division at Scottish Government. For further information please go to: www.epicscotland.org

We are very grateful to the participants of the scenario planning workshop held in October 2016. In particular, we would like to acknowledge and thank the illustrator, Tony McKay, for his significant contribution to the artistic direction and vision for the workshop and this report. Tony created 84 individual images, one for each of the drivers used in the prioritisation exercise. He also produced a historical timeline, images for each of the scenarios and an overall design language for the look of the workshop materials. The value of his contribution cannot be overstated and was noted by nearly all participants.

We thank Professor Dominic Mellor, Professor Alistair Stott, Drs. Giles Innocent, Alyson Barratt and Luiza Toma for their help and support reviewing workshop drivers. We would also like to thank Auguste Brihn, Conor O'Hallaran, Fiona Allan, Frederieke Peto, Dr. Ian Hutchinson and Dr. Julie Stirling for acting as scribes for the event and Dr. Jiayi Liu for her photography.

The views expressed in this report are those of the workshop participants. These views are not necessarily endorsed by EPIC scientists. They do not represent current Scottish Government policy.

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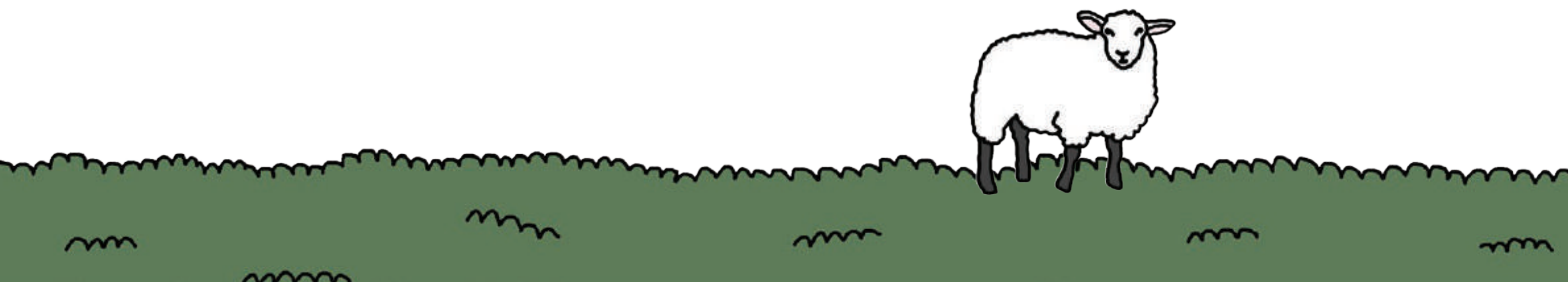
Contents



Summary

In this report, we present a description of foresighting activities undertaken by EPIC, Scotland's Centre of Expertise on Animal Disease Outbreaks, to investigate the future uncertainty of animal health surveillance in Scotland over the long-term (i.e. 2030). Using scenario planning methodologies, we explored five plausible long-term futures to identify opportunities and challenges for early diagnosis and detection of exotic, endemic and novel animal and zoonotic diseases. These scenarios highlighted critical drivers that influence the provision of animal health surveillance services including: international trade policy (i.e. globalist versus isolationist world views), data sharing philosophies (i.e. integrated versus segregated data sharing) and private versus public resourcing of surveillance capacity. Although not an original aim, the timing of the workshop meant that all of these futures also incorporated a vision of Scotland (and Scottish agriculture) in a post-Brexit world and considered the associated long-term policy and economic uncertainties this creates for the sustainability of different livestock sectors. Participants in the scenario planning exercises proposed creative strategies which might either address perceived gaps in future resilience or maximise opportunities to augment surveillance resilience in each different future. Using these participant-led proposals as a starting point, we evaluated the strengths and weaknesses of ten strategies (and their feasibility, effectiveness and relevance) to improve the resilience of the long-term future of animal health surveillance and contingency planning for animal and zoonotic disease outbreaks in Scotland. We conclude by proposing a set of five important criteria which in combination, may signal on which future path Scotland is travelling and inform decisions about which of the proposed strategies make the best investment for the long-term.

Main Messages

Given the high uncertainty about the most likely future that Scotland will face in 2030, it is important to invest in strategies that are sufficiently robust and beneficial to animal health surveillance in all possible futures. The results from this workshop suggest that a benchmarking scheme is most likely to be valuable in any future. This is followed by strategies to introduce legislation to enhance surveillance for novel and emerging diseases through statutory reporting of "health risk states" and grant-funded data-skills training schemes. The results of this workshop have also made it possible to consolidate five important criteria which may, in combination, indicate the increasing likelihood of one future over another. These are broadly encompassed by shifts in: farmer demographics, technology uptake, attitudes towards data commoditisation, surveillance submission rates by currently available routes and significant political shifts and public perceptions about evidence.

Animal Surveillance

Animal health surveillance systems are critical for understanding the risks of animal and zoonotic disease incursion, exposure and transmission, enabling early warning of exotic or novel and emerging diseases, and monitoring disease trends to facilitate effective disease control measures. Surveillance also applies to "detection of chemical contamination or toxicity … and …animal conditions, which may pose a threat to human health – either directly, or via food products - even where such conditions are not apparent in the animal itself." (Kinnaird Report at page 2).

Surveillance data are necessary precursors for the development of risk analyses for international trade to substantiate sanitary measures and support effective decision-making to mitigate the consequences of large-scale disease outbreaks (as evidenced by the Foot-and-Mouth disease outbreaks in the UK in 1967 and 2001). Epidemiologists are also dependent on high quality health surveillance data to characterise, quantify and prioritise the risks that animal and zoonotic diseases pose for the near future. Surveillance data are used in the parameterisation of probabilistic forecasting models and risk assessments. However, these models can not always take into account the uncertainty associated with "known unknowns" including climate change, consumer preferences, politics, commerce and technology. Furthermore, they can never incorporate "unknown unknowns" (e.g. the occurrence of shock events like natural disasters, terrorism political conflicts/war or extreme weather events) which may have unintended and indirect consequences for disease risks, but may also compound risks to disease detection over very long time periods. The Kinnaird Report (2011) describes a comprehensive history of animal health surveillance in Scotland. We do not seek to replicate that information here. However, for context, we have provided a summary of some key events that have shaped present-day animal health surveillance services.

Key Developments in Veterinary Surveillance in Scotland

- In the UK, animal disease outbreaks have been a major driver for investment in veterinary surveillance capacity (e.g. Foot-and-Mouth disease outbreaks between 1920s-1950s, 1967, 2001; compulsory TB testing in 1950s)

- In Scotland, surveillance began with the establishment of Veterinary Investigation Centres (VICs) linked to regional agricultural colleges

- VICs were established to provide consultancy and diagnostic services to farmers

- The scope of the VICs expanded to include support for government vets in national disease eradication programmes and working with academics and industry to solve animal production problems (Rayner Review 1984). This scope subsequently increased to include identification of new and emerging diseases (Dawson Report 1990)

- In the 1990s, the VICs were brought together under the leadership of a single Director and the three agricultural colleges merged to form the Scottish Agricultural College (SAC)

- Rapid data sharing and new technologies for surveillance were identified as a major challenge for Scottish surveillance (Scudamore Review 1993). After the 2001 FMD outbreak, data sharing was prioritised and a data-sharing warehouse was established (RADAR). New technologies and computer processing enabled improvements to the electronic identification and tracking of cattle (and subsequently sheep) movements

- In 2011, the Veterinary Laboratories Agency eventually amalgamated with the Animal Health Agency to form the Animal Health and Veterinary Laboratories Agency (AHVLA, which became Animal and Plant Health Agency, APHA in 2014) and an AHVLA laboratory in Scotland was co-located with Moredun Institute. The AHVLA's collaboration with SAC through the adoption of common protocols and definition of disease conditions improved surveillance and generated the first GB-wide quarterly livestock surveillance reports

- The Scottish Veterinary Investigation Centres were renamed "Disease Surveillance Centres" to highlight their primary role for government

- The first independent review of animal health surveillance in Scotland, the Kinnaird Report (2011), investigated the resiliency of active and passive surveillance activities to determine whether these met the needs of Scottish Government stakeholders. The report concluded that important gaps remained in data collection and sharing, particularly in rural, remote areas

What is Scenario Planning ?

Scenario planning is a tool to enable qualitative, structured, medium to long-range strategic thinking about possible futures. It depends on strong trans-disciplinary collaboration between scientists, industry representatives, policymakers and relevant stakeholders. The process includes the systematic examination of current trends and foreseeable developments that are played out in plausible ways to create a road-map to different future scenarios. This process also considers potential threats and opportunities, including those at the margins of current thinking and planning.

It is important to emphasise that the scenarios are not predictions of the future, but rather tools for thinking about how policies put in place today may help to maximise opportunities, or mitigate threats, that could occur in the future.

Participants were invited to attend a two-day event, held in Edinburgh. They comprised a multidisciplinary audience (~40 people) from diverse backgrounds including: farming (pigs, poultry, cattle and sheep sectors), companion animal sectors (small animal and equidae), wildlife conservation, environment and climate change, economics, social science, digital data management and preservation, veterinary medicine, epidemiology, law and policy (represented by participants from both Scottish Government and UK- level organisations and agencies). Participants were given the role of scenario planners, tasked with engaging in strategic thinking through a series of carefully crafted exercises that resulted in the creation of five scenarios describing the situation in 2030.

The scope of this study was encapsulated in the following focal question: “Year 2030: What is the future of animal health surveillance in Scotland?” The aim of this study was to generate a series of diverse, plausible (but not necessary probable) future scenarios to explore and future-proof the resilience of different types of anticipated surveillance systems. For the purposes of this study, the definition of surveillance was taken from the Kinnaird Report (2011) and was considered to include the continuous detection of the occurrence and distribution of hazards (including diseases, infections or health syndromes) for livestock, wildlife, domestic animals and human public health. Surveillance includes data collection, analysis and sharing to support decision-making to inform risk analysis.

Developing Scenarios

Basic trends were considered through the creation of a historical timeline. This process involved the identification and verification of important past events and influences (drivers) on the development of the present day animal disease surveillance strategy. Participants ranked these drivers according to their relative impact and then uncertainty (i.e., the greater the range of plausible outcomes of a driver, the greater the uncertainty). When there was substantially polarised discussion over the uncertainty associated with a driver, this was taken as evidence that the driver should be assessed as having high uncertainty. High impact, high uncertainty drivers (critical uncertainties) were used to develop five future scenarios. High impact, low uncertainty drivers were flagged for ongoing consideration as part of the discussion and development of each scenario.

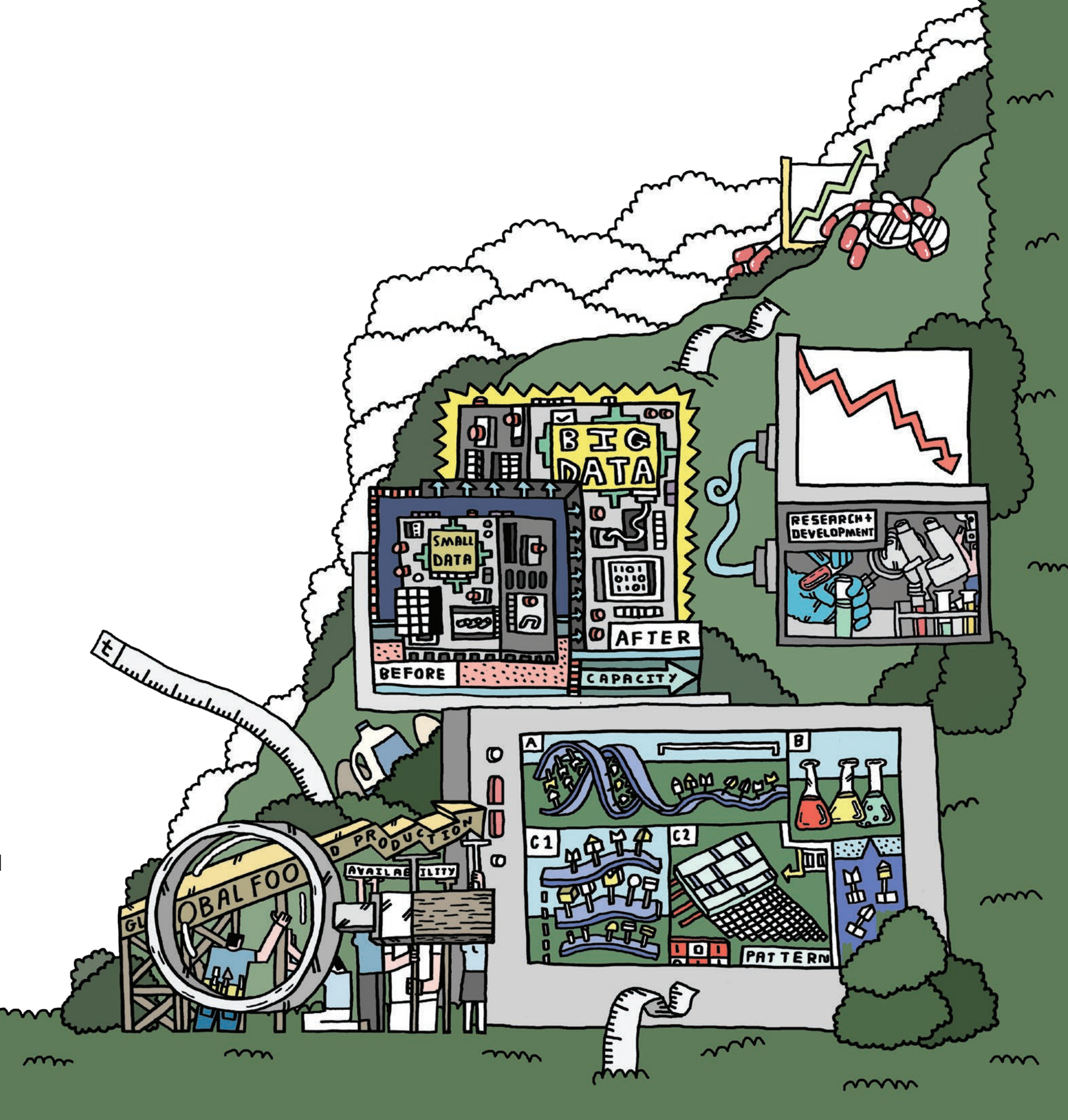
Five preliminary scenario narratives were constructed by participants to represent possible futures at different points along three key axes of change, along which a set of drivers could be represented (see Figure 1 and the following section). Scenarios were refined over the course of the workshop by participants and in post-hoc discussions amongst EPIC scientists. Best- and worst-case scenarios were avoided to ensure that the identified scenarios represented a realistic combination of threats and opportunities. Once preliminary scenarios for each future were characterised, a "back-casting" exercise was undertaken to identify specific events along the timeline and determine whether events unfold in a plausible manner along the time-line between 2016 and 2030.

The preliminary scenarios were used to prompt participants to consider potential challenges and opportunities in each future. Finally, the preliminary scenario narratives were used by participants as decision tools to stimulate imaginative discussion within the workshop about strategies which could be implemented in 2016 to improve resilient surveillance systems by 2030. The robustness of a selection of strategies was compared across all five scenarios within the constraints of the workshop. Subsequently, EPIC scientists performed an in-depth analysis of the perceived strengths and weaknesses of 10 strategies across every scenario to identify which of these were comparatively most robust given multiple uncertainties in any future.

Within the workshop, all participants agreed to Chatham House Rules. Although scribes recorded notes of plenary and small group discussions, all opinions and contributions were anonymous and aggregated in narrative form. This workshop received ethical approval from the University of Glasgow.

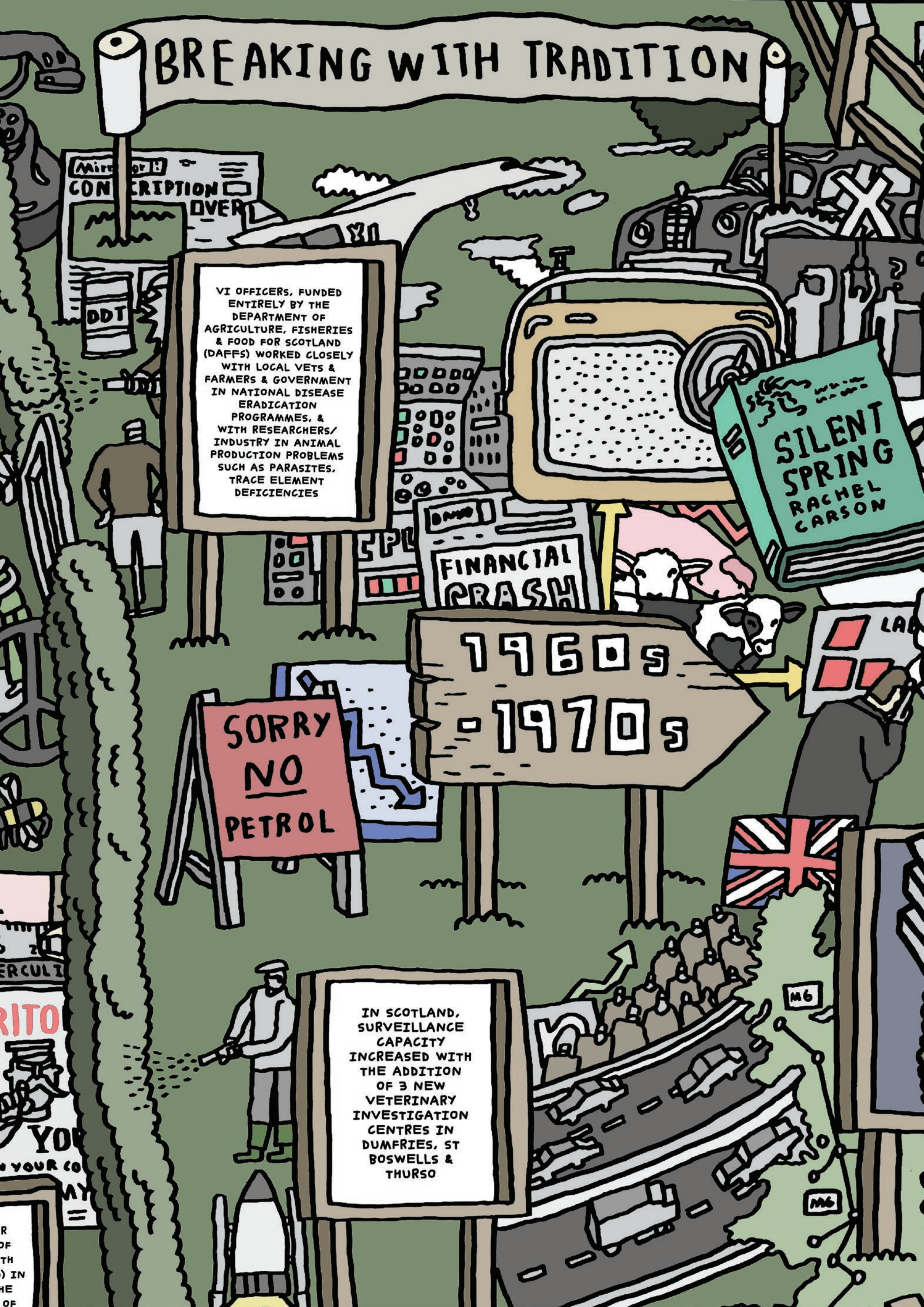
Historical Timeline

A historical timeline was developed to encourage participants to think about and discuss drivers that have influenced animal health surveillance in Scotland since 1940 to the present-day (2016). This timeline considers important factors, which have had a direct impact on the evolution of surveillance as well as other exogenous factors, which may have had an indirect impact (see Appendix).




WAR, THEN PEACE
1940s -1950s
£ TAX
DDT
VETERINARY INVESTIGATION
THE FIRST VETERINARY INVESTIGATION CENTRE WAS SET UP IN WALES IN 1922, ATTACHED TO A LOCAL AGRICULTURAL CENTRE
COLLEGE
INTRA NET
NHS
AFTER THE WAR, VI CENTRES IN ENGLAND & WALES CAME UNDER THE CONTROL OF THE CENTRAL VETERINARY LABORATORY IN WEYBRIDGE FORMING THE VETERINARY INVESTIGATION CENTRE
THE CVL HAD BEEN SET UP TO CONTROL AN OUTBREAK OF SWINE FEVER (PRE 1900) & IT THEN BECAME PART OF THE MINISTRY OF AGRICULTURE FISHERIES & FOOD (MAFF)

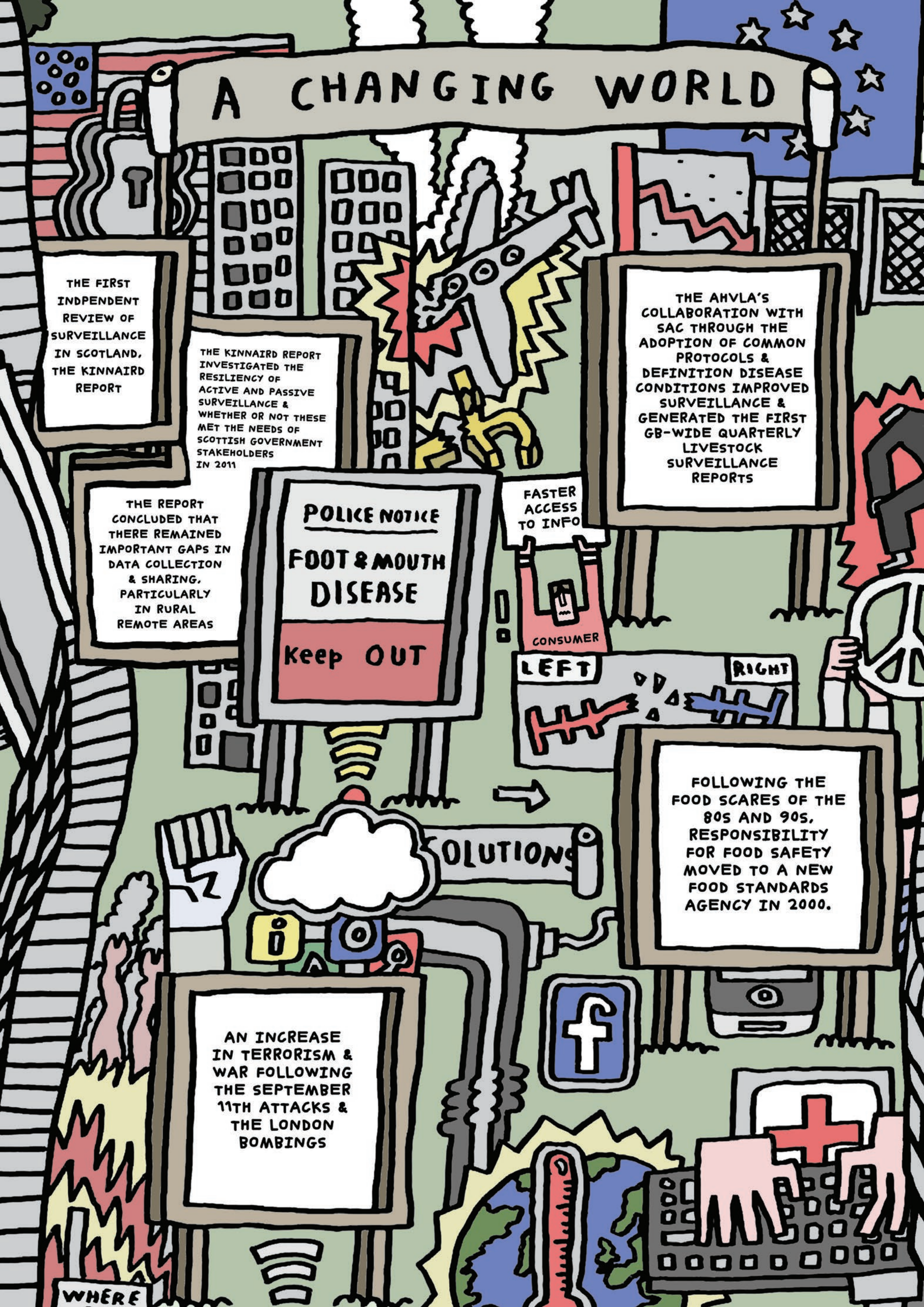

COMPULSORY TUBERCULOSIS TESTING WAS INTRODUCED
INDUSTRY FUNDING
BRUCELLA
LAB
LAB
A POST WAR OUTBREAK OF FOOT & MOUTH DISEASE (FMD) IN 1952 SAW THE BEGINNING OF A MAJOR EXPANSION TO INCREASE FACILITIES AT PIRBRIGHT FOR VIRUS RESEARCH
BY THE END OF THE 50S, THERE WERE ALSO VETERINARY INVESTIGATION CENTRES IN INVERNESS, OBAN AND PERTH
RATION BOOK
BUTTER
TRADE UNION
FOOT & MOUTH DISEASE OUTBREAKS WERE REASONABLY COMMON, ESPECIALLY BETWEEN 1954 & 1967
D.D.T
ETHICS IN VETERINARY
THE UK STATE VETERINARY SERVICE WAS WELL PREPARED FOR OUTBREAKS DURING THIS TIME
EPIDEMIOLOGY
IN SCOTLAND, THE THREE COLLEGES OF AGRICULTURE INITIALLY ESTABLISHED VETERINARY INVESTIGATION CENTRES IN AYR, ABERDEEN & EDINBURGH TO PROVIDE ADVISORY CONSULTANCY & DIAGNOSTIC SERVICES ON FARM ANIMAL DISEASES & TO SUPPORT EDUCATION, & RESEARCH & DEVELOPMENT

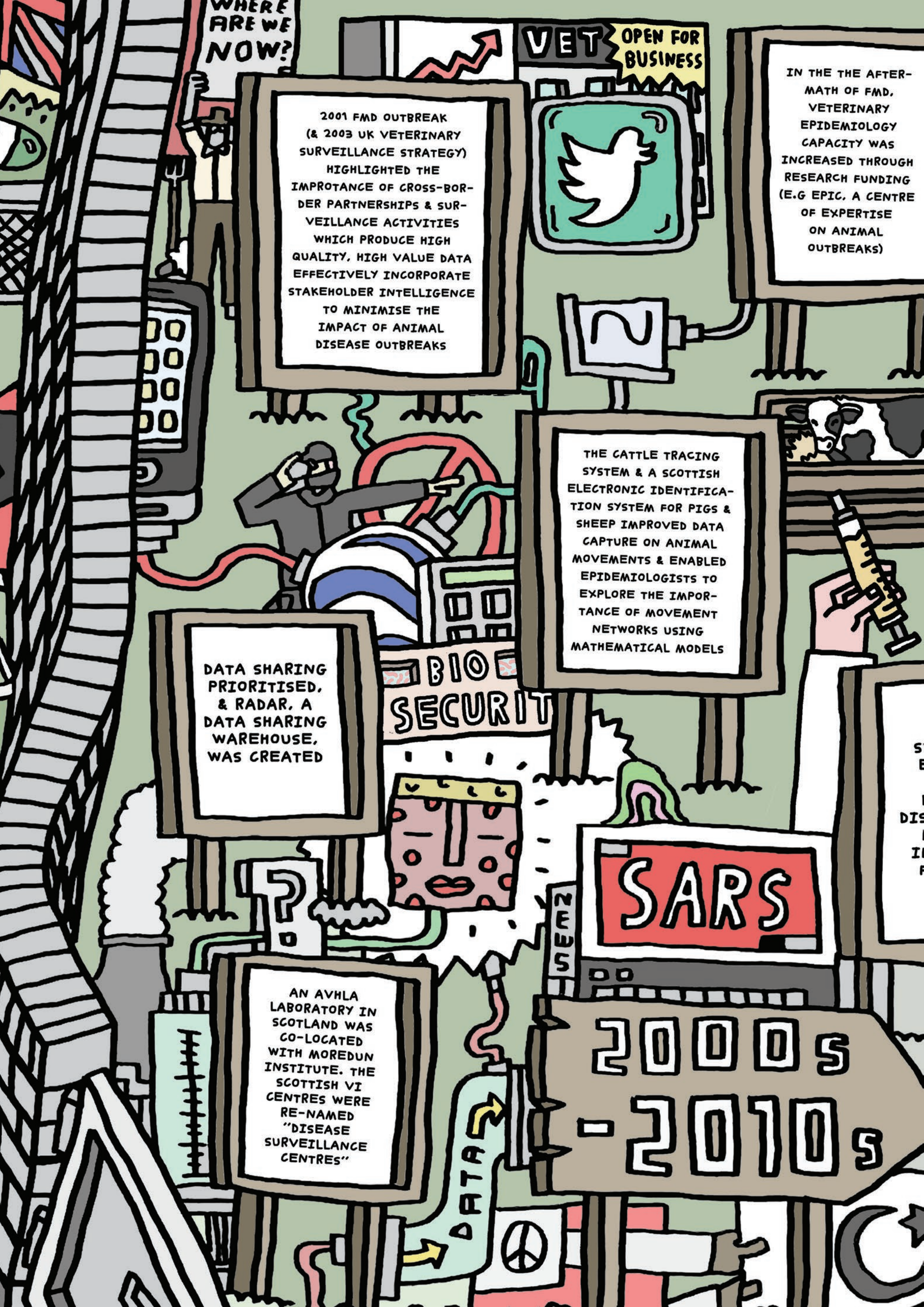

BREAKING WITH TRADITION
DDT
VI OFFICERS, FUNDED ENTIRELY BY THE DEPARTMENT OF AGRICULTURE, FISHERIES & FOOD FOR SCOTLAND (DAFFS) WORKED CLOSELY WITH LOCAL VETS & FARMERS & GOVERNMENT IN NATIONAL DISEASE ERADICATION PROGRAMMES, & WITH RESEARCHERS/ INDUSTRY IN ANIMAL PRODUCTION PROBLEMS SUCH AS PARASITES, TRACE ELEMENT DEFICIENCIES
SILENT SPRING RACHEL CARSON
FINANCIAL CRASH
1960s -1970s
SORRY NO PETROL
IN SCOTLAND, SURVEILLANCE CAPACITY INCREASED WITH THE ADDITION OF 3 NEW VETERINARY INVESTIGATION CENTRES IN DUMFRIES, ST BOSWELLS & THURSO
M6
M6


BY THE END OF THE 1960s, TUBERCULOSIS IN CATTLE HAD ALMOST DISAPPEARED AS REACTORS WERE IDENTIFIED & REMOVED
THE 1967 FOOT & MOUTH OUTBREAK – A CATALYST FOR CONTINGENCY PLANNING FOR OUTBREAKS, ILLUSTRATING THE NEED FOR EARLY DETECTION OF DISEASE
MID 1970s, ALL THE CATTLE HERDS IN THE UK HAD BEEN CLEARED OF BOVINE TUBERCULOSIS (ALTHOUGH NOT ALL AT THE SAME TIME)
VACC
10
JOBS
Mirror
UNEMPL
MENT
2 MIL


GREED IS GOOD
ANTI
CASES OF TUBERCULOSIS (TB) IN ENGLAND & WALES BEGAN TO RISE AGAIN
IN 1995, VI CENTRES IN ENGLAND & WALES AMALGAMATED WITH THE CVL TO FORM THE VETERINARY LABORATORIES AGENCY (VLA)
KW
KW
AN INTERNAL REVIEW OF SURVEILLANCE IN SCOTLAND HIGHLIGHTED THE CHALLENGES OF DATA WASTAGE & THE IMPORTANCE OF CONSIDERING NEW TECHNOLOGIES TO IMPROVE RAPID DATA SHARING
1998
new Lab
STRI
THE UNION
LABOUR
50♀/50♂
THE 3 COLLEGES OF AGRICULTURE WERE MERGED TO FORM THE SCOTTISH AGRICULTURAL COLLEGE (SAC) & THE VETERINARY ADVISORY PROGRAMME WAS ESTABLISHED TO RECEIVE DIAGNOSTIC MATERIALS
PEOPLE march FOR JOBS
TB FIRST DETECTED IN BADGERS IN 1971
1980s -1990s
COAL NOT DOLE
M1


PROTECT BADGERS
PROTECTION ORDER
QUALITY
IN SCOTLAND, THE SURVEIL-LANCE CENTRE IN OBAN CLOSED & REMAINING VI CENTRES WERE BROUGHT TOGETHER UNDER A SINGLE DIRECTOR
THE CITY
ARGENTINA SURRENDERS
B.S.E
GB
THE WORLD TRADE ORGANISATION TREATY IN 1995 DEFINED ANIMAL HEALTH STANDARDS FOR TRADE, ADDING IMPORTANCE TO SURVEILLANCE SYSTEMS TO PROVE DISEASE STATUS
THE SCOPE OF VI CENTRES WAS EXPANDED TO INCLUDE EMPHASIS ON IDENTIFICATION OF NEW & EMERGING DISEASES
DAILY
BREAK THE
PAY NO POLL TAX
IN THE EARLY 1980S, THE MAIN AIMS OF THE VI CENTRES WERE TO SUPPORT THE STATE VETERI-NARY SERVICES IN DISEASE ERADICATION & CONTROL SCHEMES & PROVIDE ADVICE TO THE AGRICULTURAL COMMUNITY ABOUT FARM ANIMAL DISEASES
SEARCH


A CHANGING WORLD
THE FIRST INDPENDENT REVIEW OF SURVEILLANCE IN SCOTLAND, THE KINNAIRD REPORT
THE KINNAIRD REPORT INVESTIGATED THE RESILIENCY OF ACTIVE AND PASSIVE SURVEILLANCE & WHETHER OR NOT THESE MET THE NEEDS OF SCOTTISH GOVERNMENT STAKEHOLDERS IN 2011
THE REPORT CONCLUDED THAT THERE REMAINED IMPORTANT GAPS IN DATA COLLECTION & SHARING, PARTICULARLY IN RURAL REMOTE AREAS
POLICE NOTICE
FOOT & MOUTH DISEASE
Keep OUT
FASTER ACCESS TO INFO
CONSUMER
LEFT
RIGHT
THE AHVLA'S COLLABORATION WITH SAC THROUGH THE ADOPTION OF COMMON PROTOCOLS & DEFINITION DISEASE CONDITIONS IMPROVED SURVEILLANCE & GENERATED THE FIRST GB-WIDE QUARTERLY LIVESTOCK SURVEILLANCE REPORTS
OLUTIONS
FOLLOWING THE FOOD SCARES OF THE 80S AND 90S, RESPONSIBILITY FOR FOOD SAFETY MOVED TO A NEW FOOD STANDARDS AGENCY IN 2000.
AN INCREASE IN TERRORISM & WAR FOLLOWING THE SEPTEMBER 11TH ATTACKS & THE LONDON BOMBINGS
WHERE


WHERE ARE WE NOW?
VET
OPEN FOR BUSINESS
2001 FMD OUTBREAK (& 2003 UK VETERINARY SURVEILLANCE STRATEGY) HIGHLIGHTED THE IMPROTANCE OF CROSS-BORDER PARTNERSHIPS & SURVEILLANCE ACTIVITIES WHICH PRODUCE HIGH QUALITY, HIGH VALUE DATA EFFECTIVELY INCORPORATE STAKEHOLDER INTELLIGENCE TO MINIMISE THE IMPACT OF ANIMAL DISEASE OUTBREAKS
IN THE THE AFTERMATH OF FMD, VETERINARY EPIDEMIOLOGY CAPACITY WAS INCREASED THROUGH RESEARCH FUNDING (E.G EPIC, A CENTRE OF EXPERTISE ON ANIMAL OUTBREAKS)
THE CATTLE TRACING SYSTEM & A SCOTTISH ELECTRONIC IDENTIFICATION SYSTEM FOR PIGS & SHEEP IMPROVED DATA CAPTURE ON ANIMAL MOVEMENTS & ENABLED EPIDEMIOLOGISTS TO EXPLORE THE IMPORTANCE OF MOVEMENT NETWORKS USING MATHEMATICAL MODELS
DATA SHARING PRIORITISED, & RADAR, A DATA SHARING WAREHOUSE, WAS CREATED
BIO SECURIT
SARS
NEWS
AN AVHLA LABORATORY IN SCOTLAND WAS CO-LOCATED WITH MOREDUN INSTITUTE. THE SCOTTISH VI CENTRES WERE RE-NAMED "DISEASE SURVEILLANCE CENTRES"
DATA
2000s - 2010s

Drivers of Change

High impact and high uncertainty drivers (critical uncertainties) were prioritised by participants (see Table 1), in order to construct three axes along which a logical and systematic grouping or cluster of drivers of change could be represented (Figure 1). The three axes included:

Trade

Isolationist versus globalist policies were contrasted. An isolationist world-view was considered to be risk averse, with a strong Scotland and/or UK focus. Trade is probably conducted via bilateral trade agreements under flexible trade terms. In contrast, a globalist view was considered to be driven by international demand for products. International movements of animals, people and products are likely to be frequent. Any restrictions to such movements will be based on international trade standards and levels of perceived risk.

Resources

Private versus public funding sources were contrasted. Private funding of surveillance comes from individuals, private companies or industry, perhaps through levy schemes. In futures where surveillance is publicly funded, surveillance is considered a public good and thus investment is a societal responsibility. There are government incentives and programmes for surveillance leading to greater government control over the strategy and ownership of any data collected.

Data sharing

Segregated versus integrated data sharing philosophies were contrasted. Segregated data acquisition and sharing implies that data are kept in private repositories without sharing or communication of raw data or results from analyses between collectors or curators. Data sharing isn't legislated for, encouraged or funded and there is a strong focus on data security and privacy. In contrast, integrated data acquisition and sharing implies open data access and sharing (with an opt-out rather than opt-in system of participation). Data sharing opportunities may be driven by legislation or funding. Data are likely to be stored centrally and data protection regulations will have evolved further to encourage and allow for data sharing. Critically, open data may still be anonymised when relevant.

In addition to the above, participants considered other critical uncertainties to be credible axes. These included: farming demographics (i.e. lifestyle farmer versus commercial producers) and climate change and extreme weather events. However, after exploring the extremes of both uncertainties, participants ultimately decided that these drivers would be better subsumed into the lead scenarios. Brexit was considered as an important influential driver in all scenarios. The effect of this unexpected "shock" event was assessed by some participants as having dominated scenario discussions, and as a result, perhaps excluded deeper discussion of otherwise impactful drivers. At the time of the workshop, the terms of conditions of Brexit were not known.

Figure 1. Scenario axes defined from critical uncertainties (i.e. high impact, high uncertainty drivers).

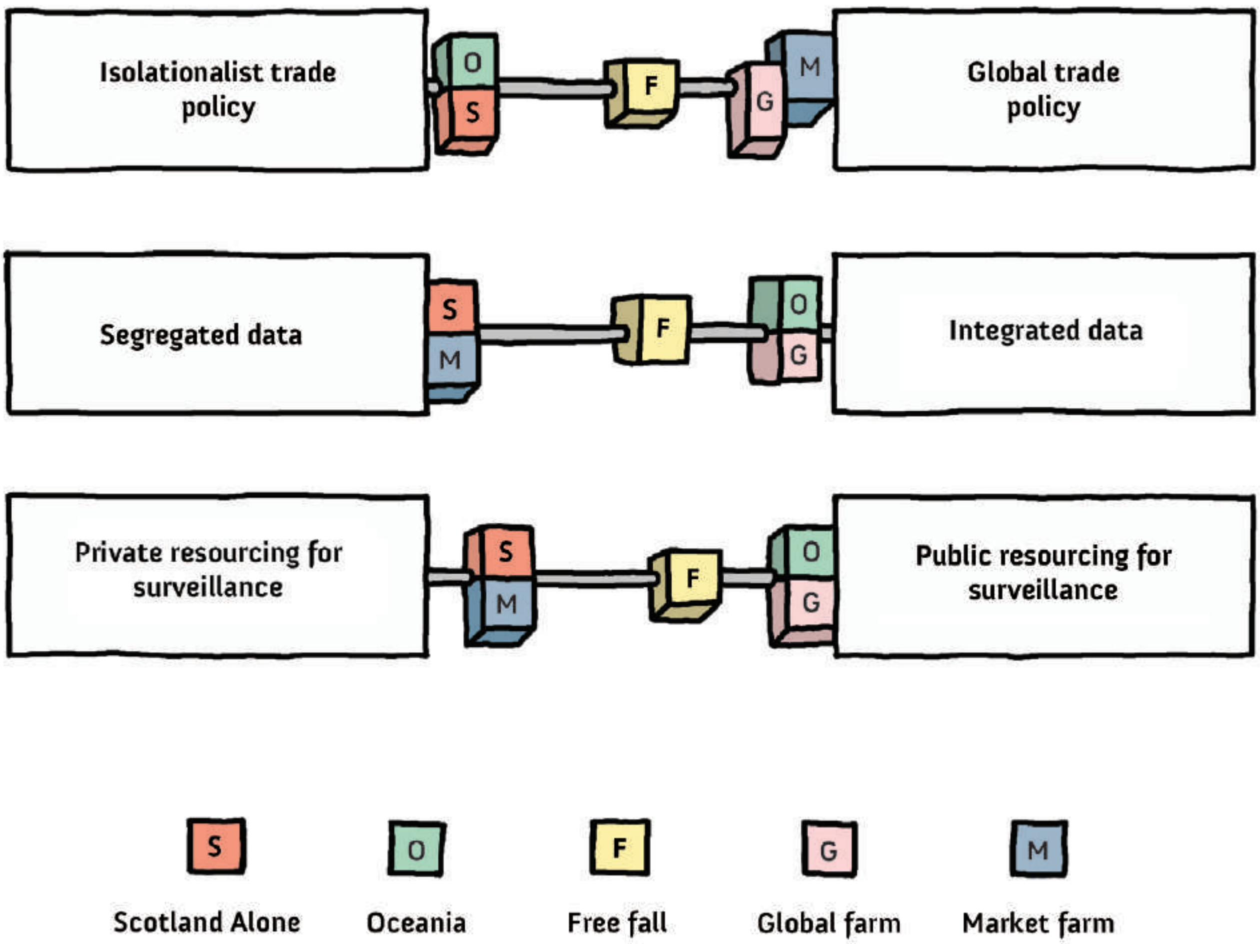


Table 1. Drivers Prioritised by Participants According to Impact and Uncertainty
For more information about these drivers, please visit our website www.epicscotland.org

	Low Impact	High Impact	
	Certainty was not considered	High Certainty (One outcome is likely)	Low Certainty (There could be multiple outcomes)
Science & Technology	Numbers of online livestock auctions Availability and uptake of personalised medicine Advances in genetics – breeding for disease resistance Improved understanding of the role of the microbiome and risk associated imports Use of genetic engineering Uptake of wearable technology Use of 3d printing for on-site diagnostic testing and treatment	Increased trans-boundary disease risks (including emerging and re-emerging diseases) Reliance on artificial intelligence Twitter and other social media used for surveillance Computing capacity to handle "Big Data" Animal and animal product traceability "One Health" initiatives in industry and government Genome sequencing Numbers of novel emerging diseases Admissibility of digital surveillance as digital evidence in court Increase in illegal movements and trade	New diagnostic technologies Uptake of precision farming Uptake of smart technology Data sharing between public health and veterinary partners
Society	Demand for ethically sourced food Industry influence Poverty in Scotland Conflict, bioterrorism and biological warfare Animal welfare Education levels	Submissions to surveillance labs Societal investment in vaccines instead of antibiotics Quality assurance schemes Inequalities in telecommunication coverage Increased knowledge and vigilance of infectious diseases Trust, integrity and reliability and authenticity of data Cross-border movements of companion animals	Location of Disease Surveillance Centres Numbers of corporate and super farms (and abattoirs) Public perception of data sharing Data protection regulations Brexit Scottish Independence

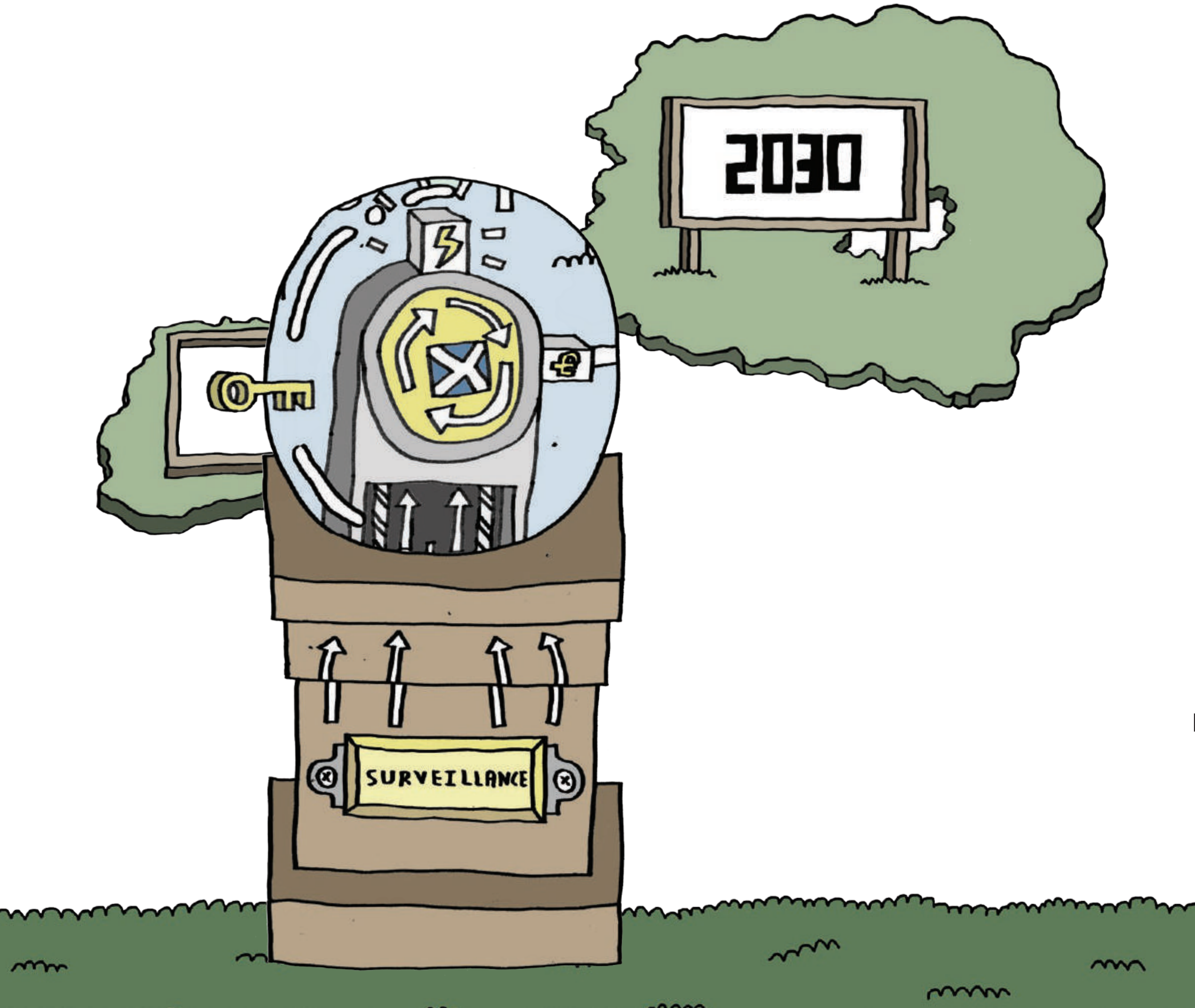
Table 1 contd. Drivers Prioritised by Participants According to Impact and Uncertainty

	Low Impact	High Impact	
	Certainty was not considered	High Certainty (One Outcome likely)	Low Certainty (Multiple outcomes likely)
Economics	Investment by "Big Pharma" into antimicrobial discovery and development Trans-Atlantic Trade and Investment Partnership National Health Service (NHS) resource requirements Oil price volatility Haulage costs within Scotland Taxation and changes in fiscal policy Market dominance of supermarket chains Volatile farm gate meat prices	Private and public spending on surveillance activities Prioritisation of surveillance by industry Spending on R&D in partnership with industry	Farm gate milk prices (and vertical integration of the supermarket chain) Perception of surveillance as private or public good Risk-based prioritisation of surveillance by government Availability of EU resources to mitigate for and control animal disease outbreaks Expenditure on veterinary education, research and development (R&D) in Scotland Prioritisation of national and international resources as a result of human pandemics Global economic prosperity Global trade of livestock products and live animals Change in global trading patterns Focus on global food security and safety
Population	World population growth Scottish population growth Ageing farmer and farm veterinarian demographics Importance placed upon food provenance	Prevalence and diversity of antimicrobial resistance (AMR) in animals and people Urbanisation in developing countries Movement of people Regional prosperity in Scotland	Rural population growth in Scotland Changing animal demographics in Scotland
Environment	Public awareness of carbon footprint Competition for land use and forestry not farming Demand for renewable energy Control of Greenhouse Gases (GHG)	Wildlife conservation and re-wilding policies Numbers and distribution of wildlife reservoirs of disease Unpredictable and extreme weather events	Climate change affecting vector and disease distribution Influence of climate change on agricultural production

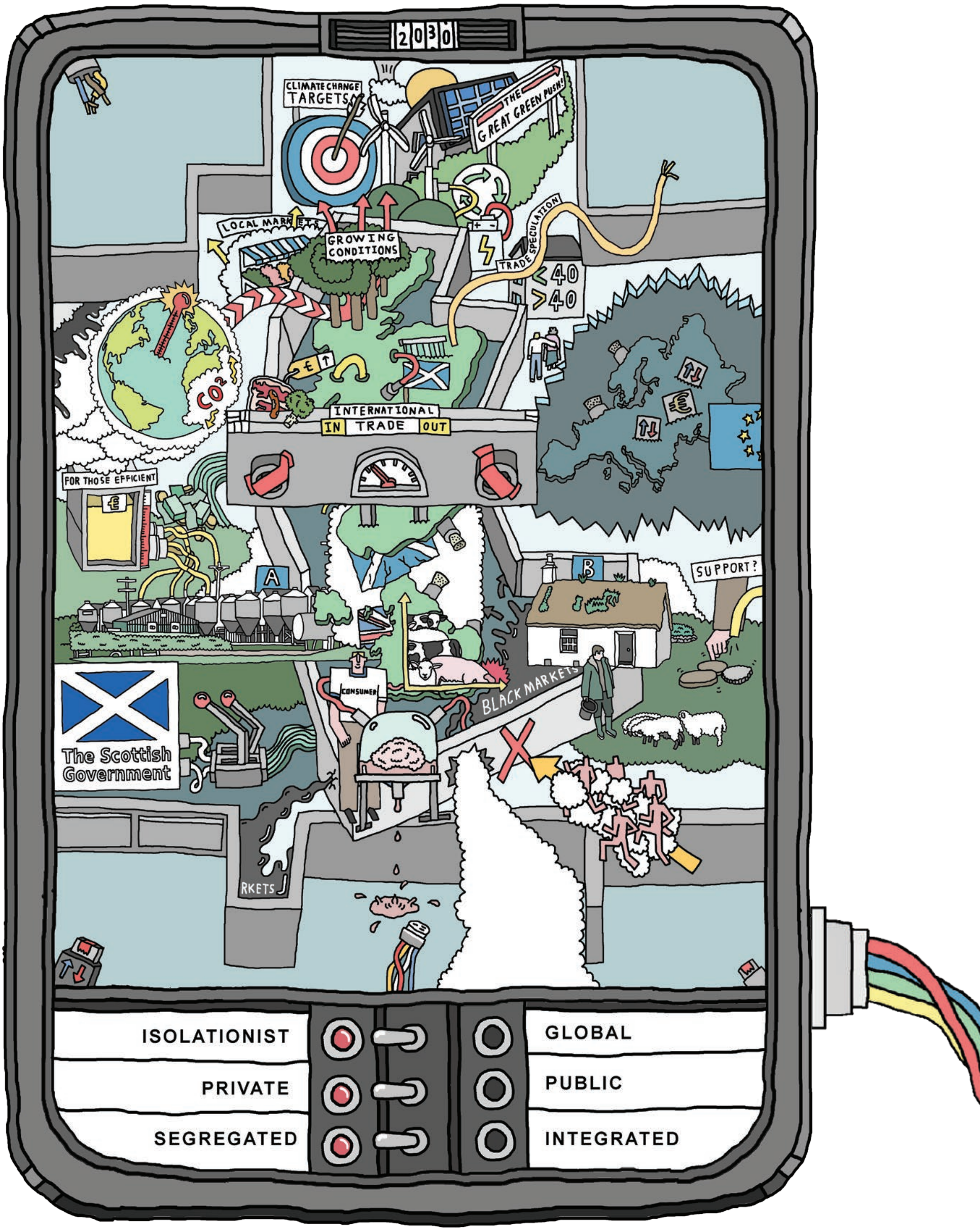
Scenarios

Five scenarios were constructed to represent potential futures at different points along the axes. Best and worst case scenarios were avoided to ensure that the identified scenarios contained a realistic mixture of threats and opportunities. Once scenarios were characterized, a 'back-casting' exercise was undertaken to identify specific events along the timeline and determine whether events unfold in a plausible manner, consistent within each scenario.

Realistic scenarios contain both opportunities and threats. A strategic approach requires exploiting opportunities and counteracting threats through the development of long-term thinking, which can be set in motion in the present day. However, the robustness of these strategies needs to be critically considered. Strategies considered desirable and effective in one scenario, can be irrelevant or even counterproductive under a different set of conceivable circumstances.

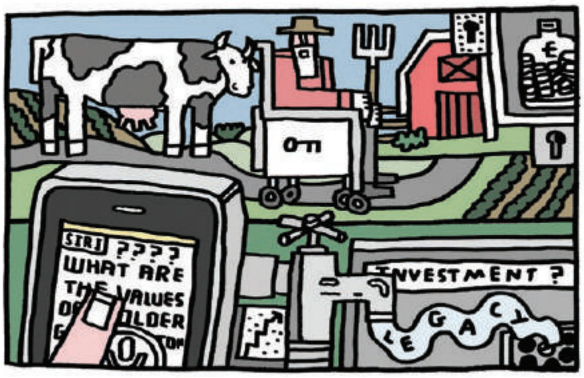


Scenario 1: Scotland Alone



The Future

Scotland in 2030 finds itself on its own: independent from the rest of the United Kingdom (UK) and no longer part of the European Union (EU). With relatively few outside resources upon which to draw, renewable energy has become an important government priority alongside efficient food production. Two main types of farms dominate the agricultural landscape: large industrial or commercial farms and small subsistence farms (which comprise hobby farmers or smallholders, communal farms and allotments). The low numbers of remaining industrial farms are motivated by profit and focused on producing animals with a high health and welfare status. Small family farms cannot compete with these larger, more efficient producers and are declining in number due to the cessation of outside support. Increasingly, the young and the old choose to live communally as they cannot afford to buy their own land, and engage in small-scale subsistence farming. There is little international trade, resulting in an improved local market, but there are fewer foreign workers on farms and higher food prices (due to lack of competition from cheaper food imports). New black markets are emerging, which are a source of disease risk.



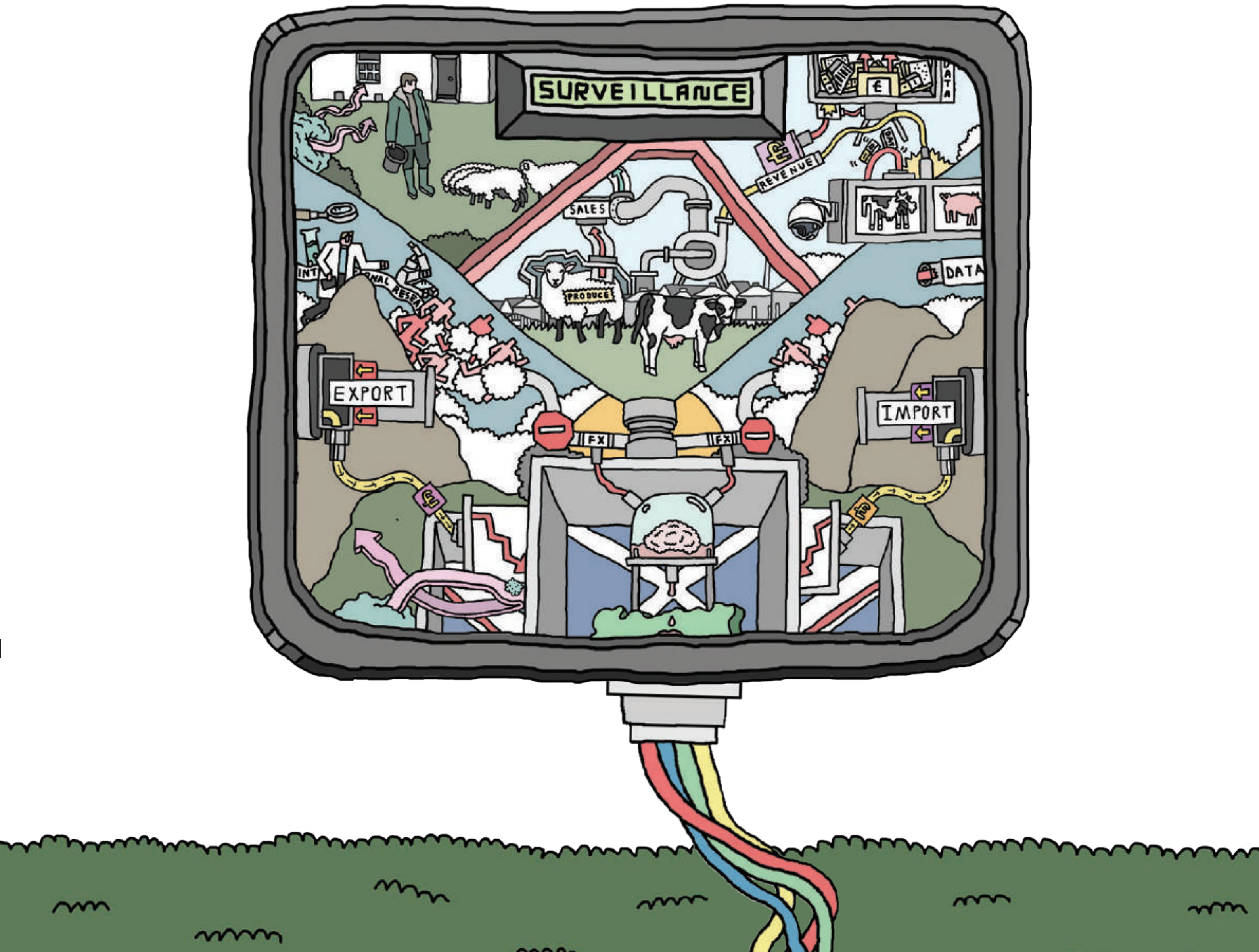
Surveillance

Closed borders (fewer imports and exports) mean there is a reduction in the likelihood of exotic animal or zoonotic disease incursions. When incursions do occur, they often go unnoticed on small-holdings and communal farms. The large number of new entrants into backyard or hobby farming, means that overall, there is a lack of institutional memory and disease vigilance and farmers are less prepared for disease outbreaks. The agricultural livestock and poultry industries are responsible for funding surveillance. As a result, data collection is limited and motivated by self-interest and personal benefit (rather than as a public good). Any surveillance data that are collected, are likely to be of high quality and targeted to the end-users' needs, but data are not shared outwith industry sectors. Limitations on immigration have resulted in a "brain drain" and fewer international researchers are attracted to research opportunities in Scotland.

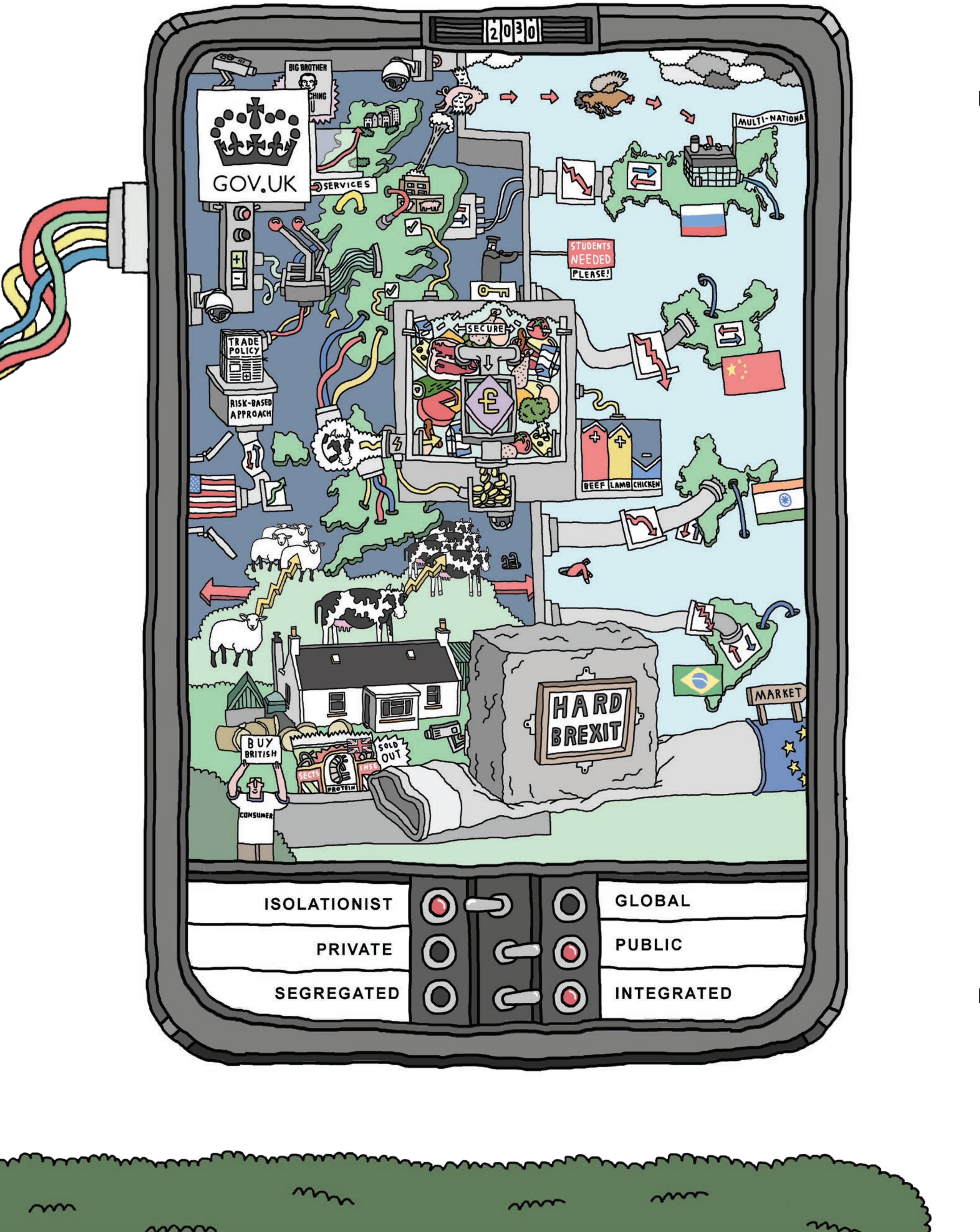
Could This Scenario Happen? A Plausible Road Map

In early 2020, Scotland and the rest of the UK were poised for a hard Brexit, and Scottish dissatisfaction ran high. In the immediate run-up to the separation of the UK from the EU, leaders of several prominent EU countries intimated that the EU might be willing to set aside its historic distaste for separationist movements in order to preserve the fundamental rights of Scottish citizens and of other EU nationals in Scotland. Scottish nationalists greeted this news enthusiastically, and called for a second Scottish referendum. The Westminster government, angered by EU interference, riding a wave of recent successes and confident of victory, agreed, in order to "settle the question of Union once and for all". Union appeared to be the voters' preferred option, until the publication of intemperate and inflammatory remarks made by a senior Government minister. Independent Scotland won the day by the narrowest of margins and formal independence from the UK was finally achieved in 2023. Although not yet a member of the EU (having formally withdrawn from the union with the rest of the then-UK a few years earlier), this situation was widely assumed to be temporary. However, this changed dramatically the following year, when the EU was shaken by the final financial default of one of its weaker economies and populist nationalist parties rose to power in several key EU states. Scotland had to stand on its own and was effectively shut out of international trade with the UK, Europe, and North America, yet remained too small a target to be of much interest to other markets. Recognising the risks of such stark independence, the Scottish Government moved quickly to shore up critical energy and agricultural capabilities, but with burgeoning health and social care obligations and limited resources, industries were left on their own to address what was perceived as primarily industry problems. Government coordination of animal disease surveillance activities effectively ceased. Limited opportunities for other employment led to creative social experiments in communal living and "back to nature" subsistence farming, the practitioners of which operated beyond the scope of industry-supported disease surveillance and control efforts. The effects of this bifurcation in how livestock and poultry are raised are now widely felt in 2030.

Opportunities	Challenges
Potential for high health status among commercial farms Potential to harness community resources for disease detection via community sharing and collective use of assays, particularly among small holdings	Limited capacity for large-scale data collection and centralisation Technology uptake is limited to cheap, robust units that result in significant cost- or labour-saving Increased new entrant famers mean there is a loss of institutional memory Limited funds or demands for biosecurity and surveillance submissions Risk of disease incursion is high – many go unnoticed and unreported Black markets/ illegal imports are commonplace



Scenario 2: Oceania



The Future

In 2030, Scotland is focused on ensuring food security through self-sufficiency. A hard Brexit in 2019 resulted in loss of market access and increasingly isolationist policies designed to protect the UK economy. Scotland's agricultural trade policy is based on a precautionary risk-based approach, which results in fewer, highly selective and low-risk transactions with trusted partners to reduce the risk of notifiable disease incursion. Trade with BRIC (Brazil, Russia, India and China) countries has declined substantially. This has downstream benefits for human health but has increased consumer costs. UK agricultural businesses have become more profitable: equilibrium prices are higher, as a result of fewer imports due to tariffs and non-tariff barriers. This situation is great for companies with a solely UK focus, but for all but niche producers, export costs are prohibitive. As a result, many multinational companies have decided to withdraw from Britain to focus on developing countries where costs of production are cheaper and where greater market access exists; the UK is no longer a good base for mass production for external markets. Some multinationals have remained in Scotland and have adapted to the new trade circumstances, buoyed by new trade access to different countries such as the USA. Production levels have become more similar to those of the 1960s, with less chicken and more lamb and beef being produced. Overall, acreage use for livestock is reduced due to competition for land use for carbon sinks, needed to meet the targets specified by the international agreements on climate change. Sheep and beef farms are increasing in size, but this does not necessarily mean greater intensification, just geographical redistribution (with more sheep and beef cattle moving to lowland areas, and marginal regions dropping out of production). Pig and poultry units have restructured into smaller units to supply national demand and many poultry units (those which are part of multinational companies) have simply moved overseas. Consumers are buying British, but as livestock numbers decline, farmers and consumers are increasingly choosing alternative protein sources. This has a knock-on impact on the veterinary and agricultural sectors, leading to reduced opportunities for employment and leading to a "brain drain" away from on-farm work. It is difficult to attract students to veterinary schools and agricultural colleges, resulting in a shift towards reliance on para-veterinary professionals and nurses. The one growth area is government service: the numbers of vets and epidemiologists directly employed by the state has increased.

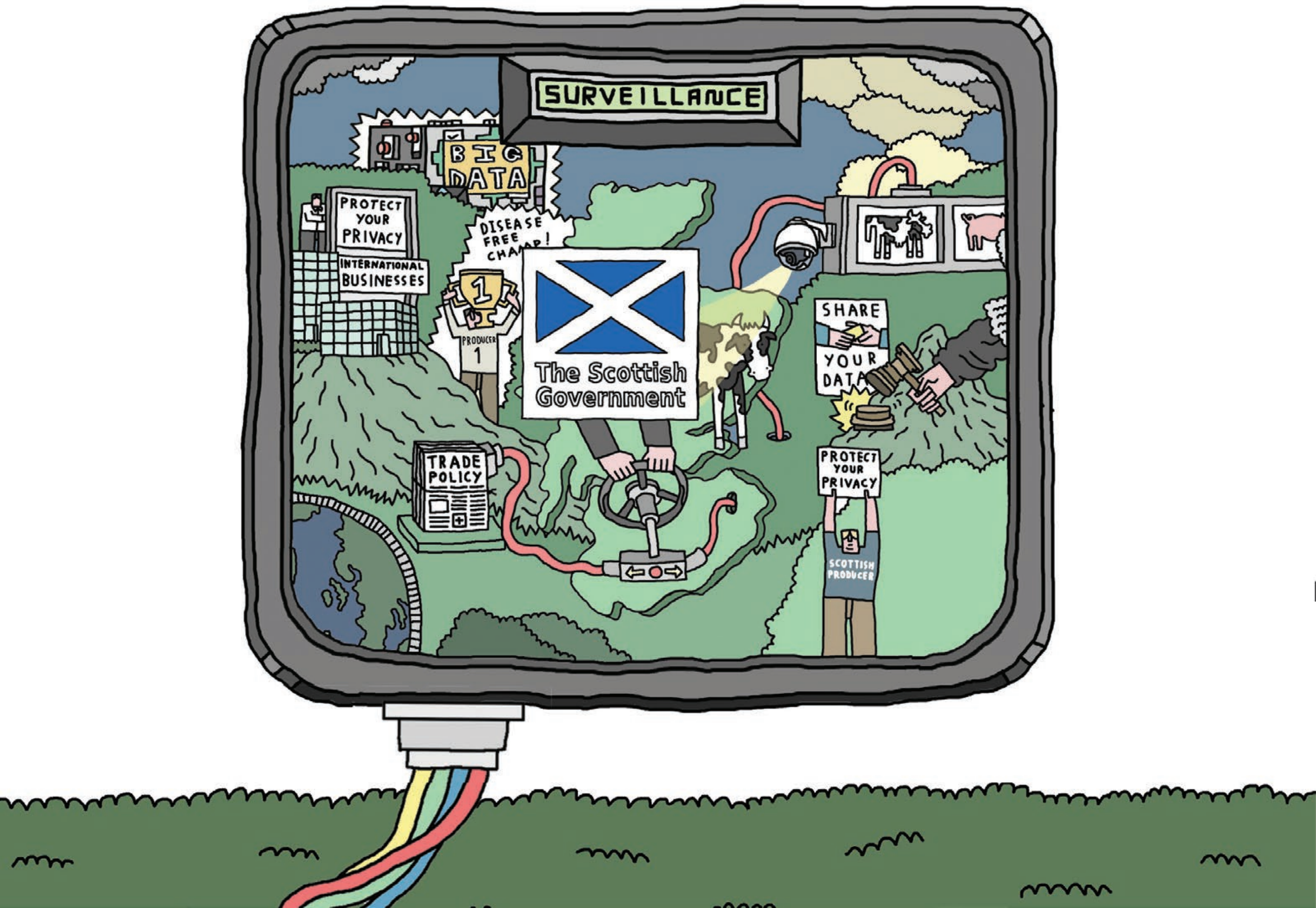
Surveillance

Trade policy and surveillance are state-driven. There is legislation to ensure compulsory data sharing: very few elements of data cannot be shared. As a result, some international businesses and Scottish producers have growing concerns about constraints on privacy in the UK; in particular, farmers are deeply concerned that they do not have exclusive ownership of their own sensitive business and animal health data, which they fear leaves them vulnerable to competitors who try to undercut production costs. Farm health status information is freely available to the public for anyone to analyse. These data are used in a "free-market" for "evidence for policy" purposes to identify high- and low-risk producers. Scottish Government has invested in analytical tools to integrate data supply chains. Internally, "Big Data" are harnessed to increase production efficiency and to reduce the prevalence of diseases of production. Producers are even ranked in disease efficiency league-tables. Within the border, animal surveillance increasingly focuses on production diseases and endemic diseases, as increases in national production are politically and socially important, and provide clear economic advantages to producers.

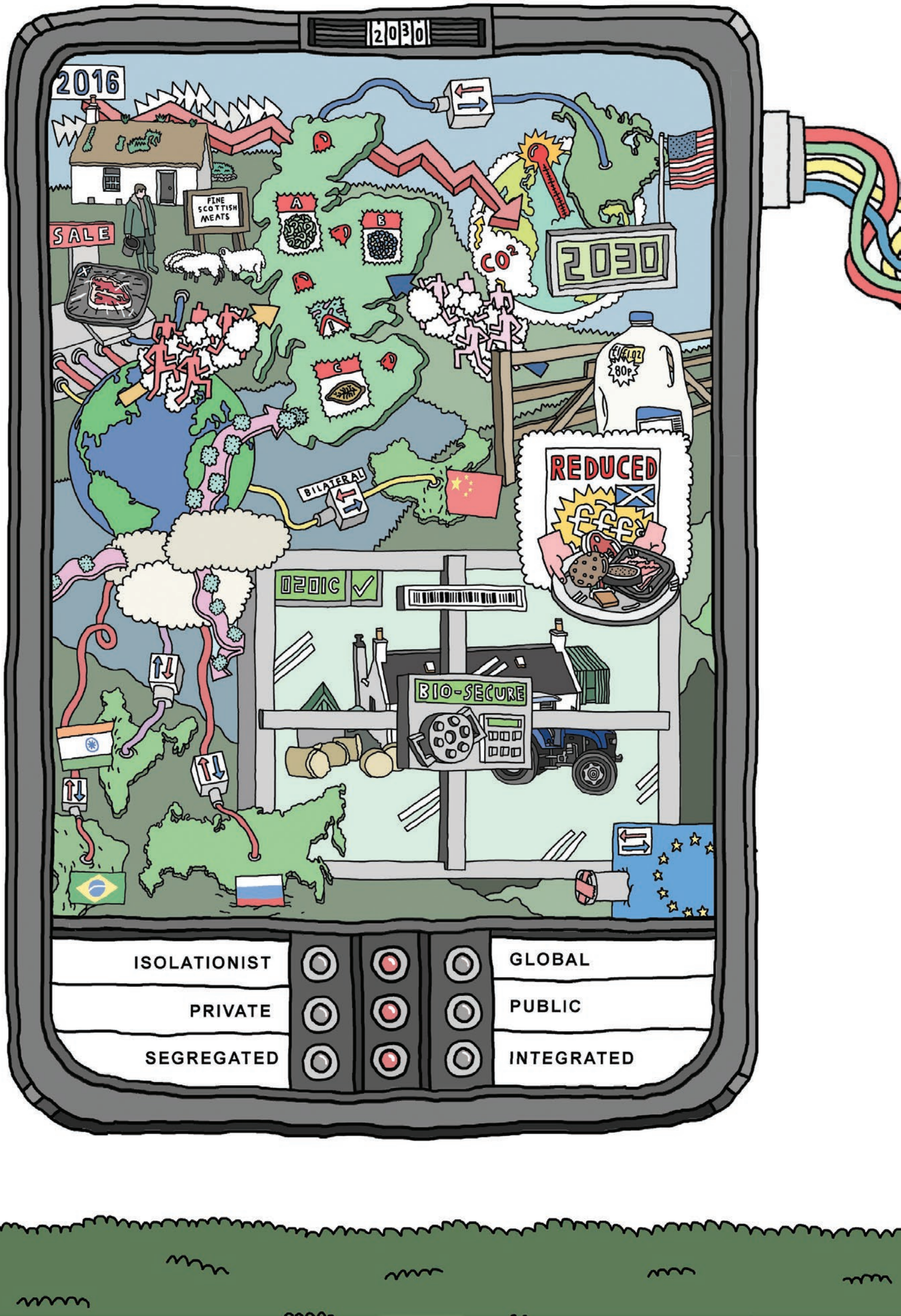
Could This Scenario Happen? A Plausible Road Map

Post Brexit, the country has been left more inward looking. International trading under World Trade Organisation (WTO) rules has proven to be unrealistic and uneconomical. In the absence of free trade deals with any major food producers, and in the face of a collapse in the value of the pound, there has been a shift towards producing and eating UK produce. Difficult trade negotiations have created a perception of other countries as competitors (at best) or enemies (at worst). One of the first trade agreements to be signed, with a South American country, led to an influx of cheap livestock products. The industry responded angrily, lobbying politicians hard about the threat to rural enterprises. Political parties in control at Westminster and at Holyrood had strong electoral bases in rural areas, and some in power were alarmed at the electoral consequences of such a "race to the bottom". Unfortunately, at this crucial point there was also a drastic shock to the system: a disease incursion with enormous public health significance was introduced into the country. Like Schmallenberg, it caused birth defects in animals. Via alt-facts spread on social media, there was enormous public hysteria about whether, like Zika virus, it might also be associated with birth defects in humans. The infection had not actually been introduced from South America, but this was not established for several months (and the tabloid press and social media were awash with alarmist stories about "neo-Zika virus" and birth defects for years to come). Testing of all livestock products before entry into the country was introduced. Initially this action was motivated by the need to be seen to be doing something proactive. The agricultural lobby and its political supporters grabbed this opportunity and successfully pushed for a trade policy which sought to protect the health status of UK indigenous agriculture by prioritising deals with countries with high standards of disease management. They were not 100% successful in this, but the idea that food should be tested before entering the country has become part of popular "common sense". As the dust settled, the industry realised that structural barriers to imports – such as sampling, testing and documenting products at official control points and laboratories, were extremely effective in reducing import levels. As a result, testing regimens were gold-plated and enforced rigorously, making maximum use of the sanitary and phytosanitary measures allowable under WTO rules. The political imperative for these activities, however, was their effectiveness as means of import control, rather than their epidemiological efficacy. The official line was that the UK set very high food-safety standards and that these were difficult to meet. However, the country had invested too much in systems for safe food production to compromise them - food must conform to very high safety standards, irrespective of its origins. Given the higher prices, there was also a political imperative to be seen to support increased agricultural productivity. The development of the internal surveillance and disease monitoring system grew out of the "corporatism" already visible in the mid 2010s where the Innovation Centres were used to promote the use of new technologies on farm, coupled with the #OpenDefra initiative announced in June 2015 promising that "this free resource of data will give space to individuals beyond government to take the initiative and pursue ideas that bring profit and progress". The novel fusion of data availability and social media made it possible for government, supermarkets, local producers and lobby groups to harness consumer concern, for example: by "naming and shaming" producers with poor track-records in disease management. All of these actors, at different times and places, have had good reasons to do this, but now technology makes it feasible for all to do so. This social authoritarianism and the risk of falling foul of it pressured producers into adoption of data driven methods to monitor and reduce losses from endemic production diseases rapidly. This proved to be highly effective.

Opportunities	Challenges
New types of training initiatives focusing specifically on technology use for data collection, analysis and interpretation A lower tolerance for diseases means that there is the potential to "benchmark" animal population health and identify lower thresholds for intervention at pre-clinical stages, improving early disease detection and reducing disease impact	"Brain drain" of veterinarians away from practice work and a reduced labour force working on farms; there is a smaller pool of veterinarians available Agricultural sector is vulnerable to government resource de-prioritisation There is a science-policy-industry disconnect and little buy-in from stakeholders who are not happy due to their lack of control over their own data and industry There are challenges regarding data analysis including: volume and provision speed of data and absence of sufficient expertise in the UK to make full use of this resource. Those best resourced to use the data are not necessarily those best placed to do it Data are democratised and potentially available even to international competitors; There are new concerns about malevolent use of data



Scenario 3: Free Fall



The Future

The world in 2030 has continued along the same trajectory since 2016. The farming sector has been hit by lower farm gate prices, reduced trade with the European Union (EU) and reduced subsidies, and is forced to slash costs, leading to a domestic market with declining quality. There are fewer medium or small-scale farming operations due to the high volatility of relevant livestock markets and the dominance of larger commercial producers. Overall, there are reductions in the national numbers of cattle, sheep and pigs relative to 2017; the Scottish poultry population has stabilised. There are also few newcomers to farming in the decade following Brexit, leading to a generational gap between farmers and loss of "institutional memory" regarding disease outbreaks. Following new bilateral trade agreements, a few farms market themselves as "Fine Scottish Meats" aimed at non-EU export markets such as the USA, and maintain high standards of biosecurity and welfare. The increase in trade and travel with non-EU countries, increased movement of people, and climate change has increased the pressure of endemic, emerging and exotic animal diseases such as liver fluke, West Nile virus (WNV), and Bluetongue virus (BTV).

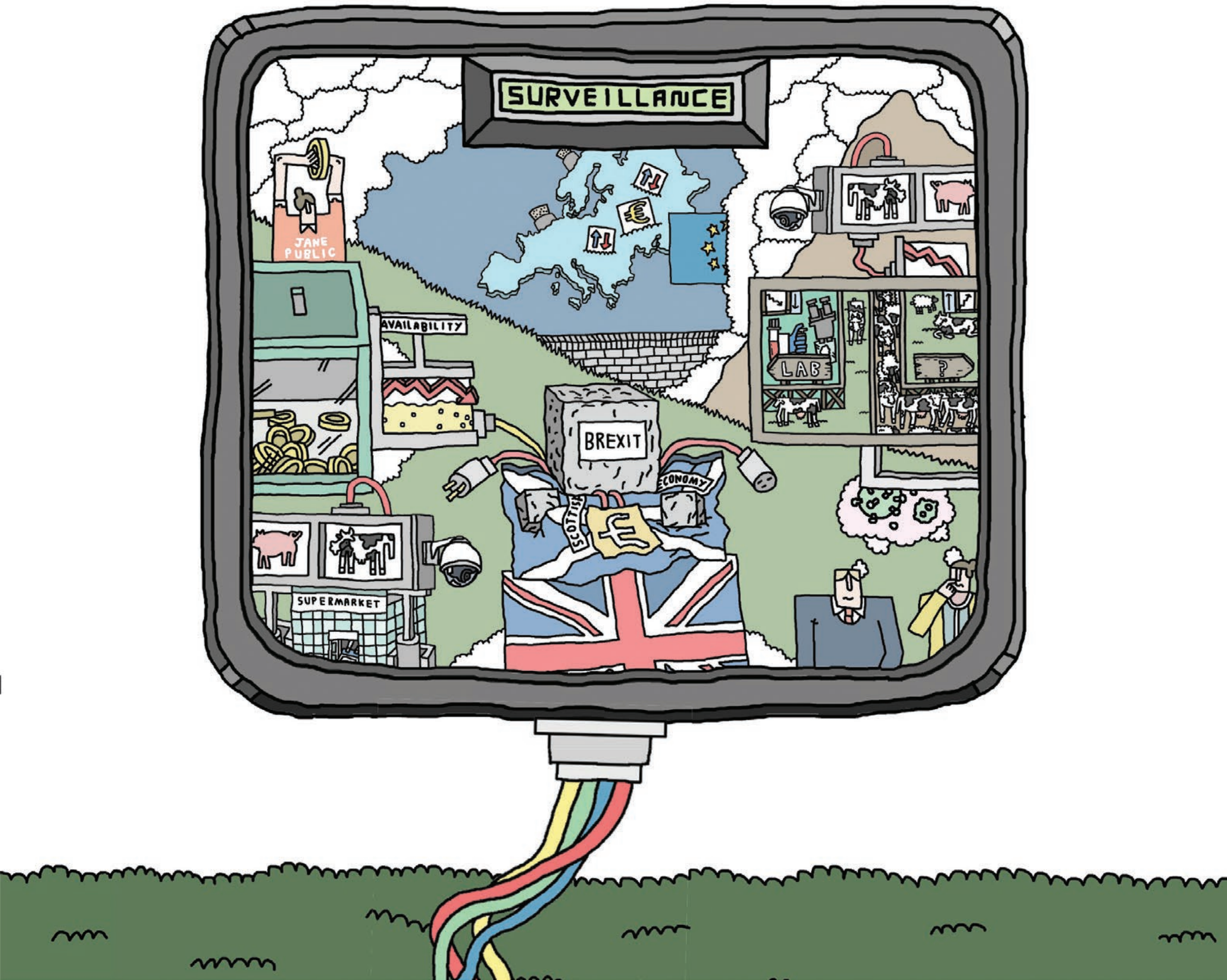
Surveillance

As a result of Brexit, the Scottish economy has shrunk, and available public resources for surveillance are limited. Surveillance is further challenged by low submission rates to veterinary laboratories and the reduced number of veterinarians in large animal practice and rural areas. Supermarket chains are responding to consumer demands for improved animal welfare and alongside industry and government, are pushing for improved disease surveillance. The disruption of established ties with the veterinary agencies of the EU has made it difficult to access international disease data. Consequently, it is difficult to prepare in advance for outbreaks. All these challenges mean that disease surveillance is focused on outbreak control rather than prevention. Fortunately, technological developments have mitigated the impact somewhat. Pen-side pathogen tests enable on-farm identification and prompt control of disease. Furthermore, social media channels such as Facebook are used to reach those affected by disease outbreaks, which has made it easier to generate engagement on issues from the general public. The challenges of infectious diseases are very much on everyone's mind in 2030.

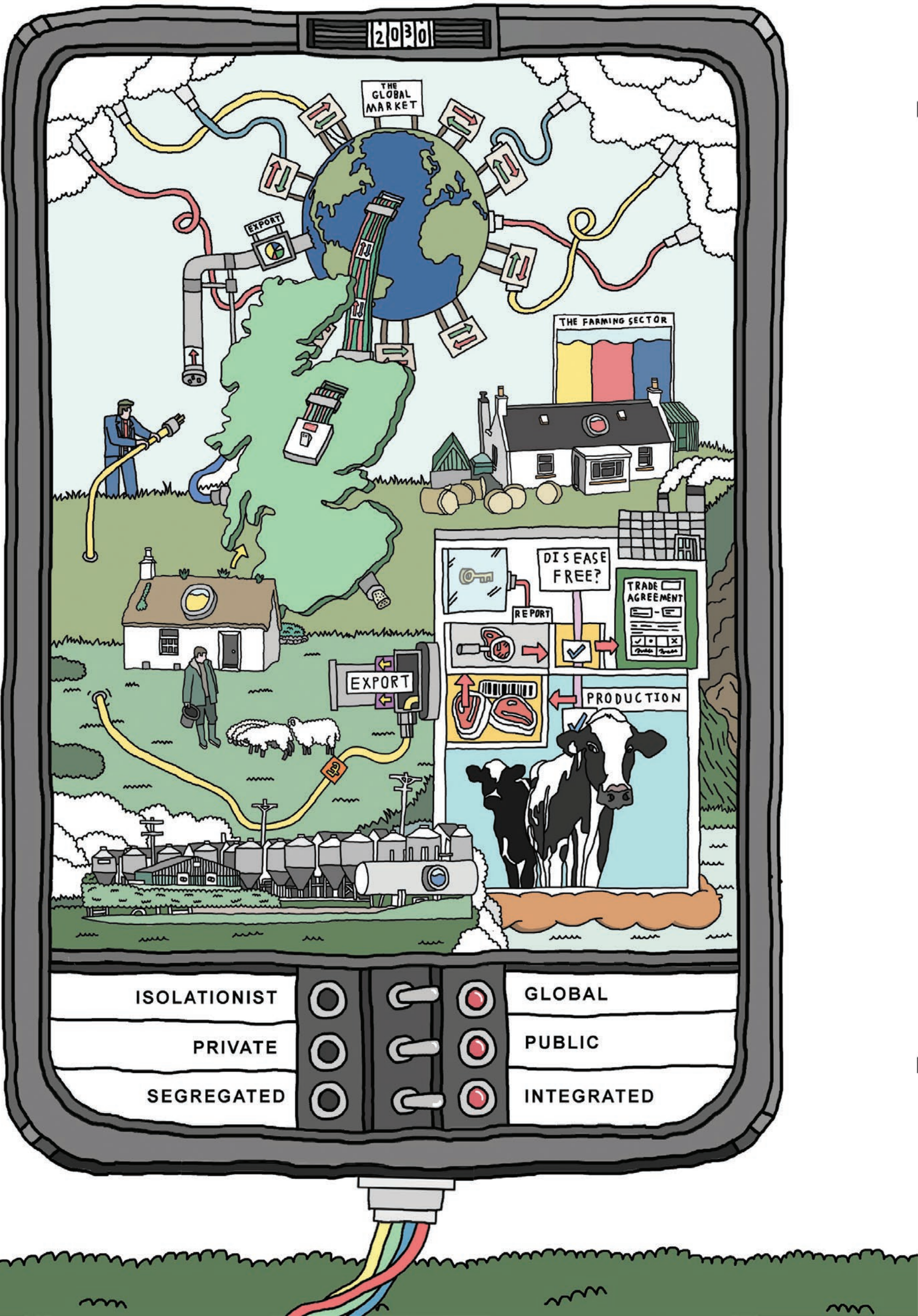
Could This Scenario Happen? A Plausible Road Map

Following the Brexit vote, the UK faced a series of challenges: high market volatility, climate change and globalisation. There was little remaining political capacity or will to address the issues faced by the livestock industry. Livestock disease management, policies and systems languished. The triggering of Article 50 in March 2017 necessitated multiple changes to animal health laws, which weren't settled until 2025. This uncertainty and a high volatility in the global animal products market scared away new veterinarians and farmers from the livestock industry, and by 2030 the industry suffers a generational gap and loss of expertise. Welfare standards dropped and there was lower adherence to disease control programs. The result was increasing prevalence of endemic diseases. Larger corporate farms and a small number of high-quality farmers stayed in business, but the overall number of farms declined, necessitating continued imports. Following Brexit, Scotland, as part of the UK established new UK-USA trade agreements, leading to greater USA and fewer EU imports. In 2020, there was a large outbreak of Bluetongue virus (BTV). Due to a warming climate, mild winters, and a lack of resources and expertise, the outbreak was never brought under control, and the virus eventually became endemic in the UK and Scotland. Mosquito abundance increased, and from 2030 a newly introduced strain of West Nile virus caused serious animal and human health risks. Electronic tags for animals became popular from 2020, and allowed automated tracking of animal movements between farms and recording of frequent health indicators at the individual-animal level. These records were slowly being adapted for use in disease surveillance and outbreak detection, but this process was hindered by the lack of open data standards. Small pen-side tests for a wide range of diseases were submitted for approval to the OIE in 2022 and brought in use by 2025, which reduced the time required to identify and respond to outbreaks.

Opportunities	Challenges
Expanding reliance on different technologies to obtain rapid real-time information in outbreaks Faster, accurate pen-side diagnostic tests available	Limited resources and a loss of farmer, veterinary and research expertise as fewer people able to stay and work, or move to the UK from abroad Under-utilised technological and data capacity and a shrinkage of surveillance infrastructure due to economic downturn, reduced human resources, and a lack of data standardisation High quality farms may not be viable unless they have invested early in developing a niche export market. Smaller farms and veterinary practices suffer in terms of buying power and social impact



Scenario 4: Global Farm



The Future

The Scottish livestock industry is buoyant, competitive and oriented towards the export market and niche product production within Scotland. This is part of a global trade market in high-end Scottish produce whereby Scotland has bilateral export agreements with a number of countries. These trade agreements are contingent upon livestock being free from disease and a transparent chain of testing records to support this. The farming sector closely resembles the sector as it is presently, with a mix of small crofters and lifestyle farmers, family businesses and large commercial farmers.

Surveillance

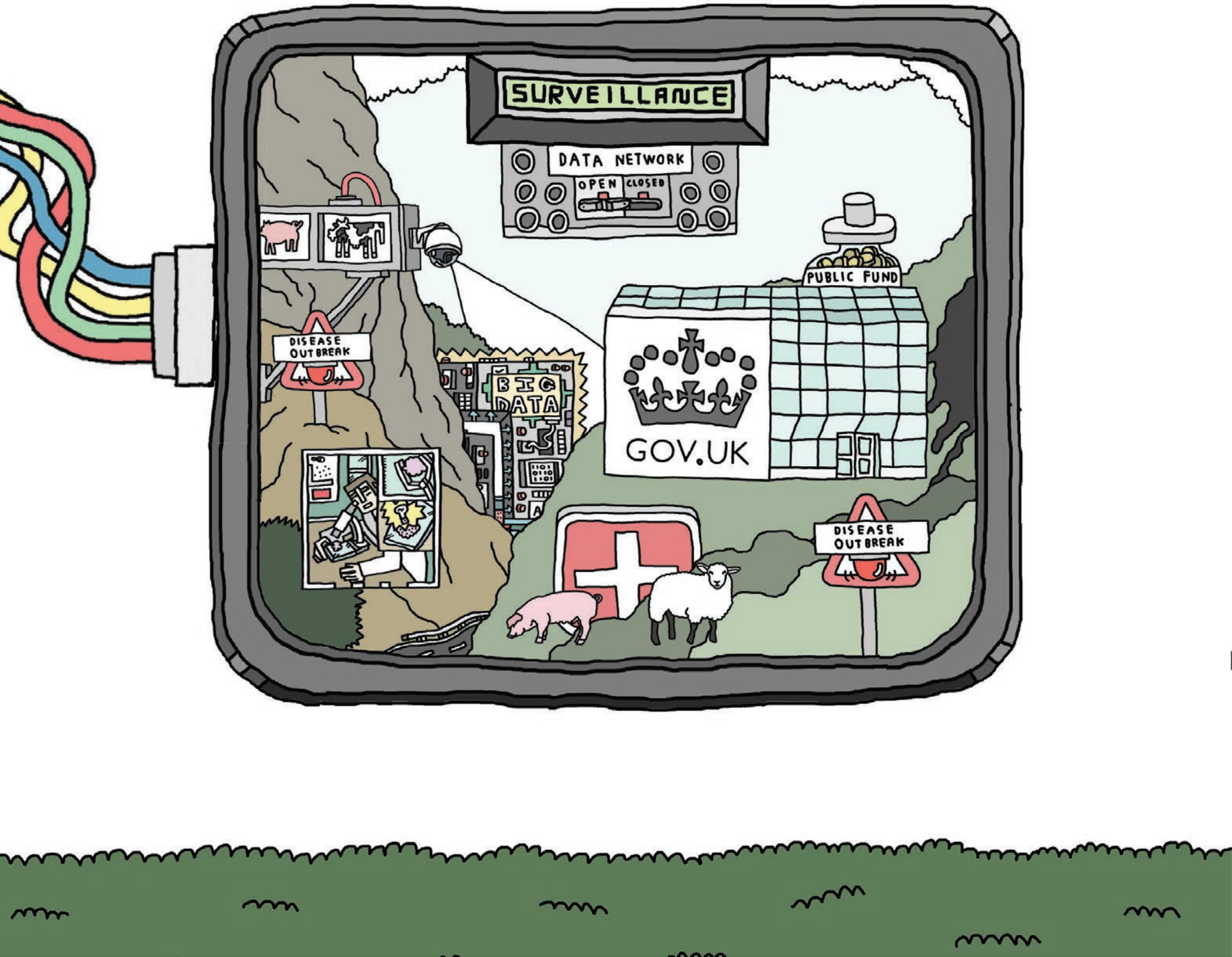
Surveillance for animal health, public health and wildlife disease is publicly funded by government, which provides grants and tax incentives for a large R&D sector and is supported by a wide range of innovative technologies. There is vertically and horizontally integrated data sharing between farmers, vets and stakeholders within and between businesses and sectors. Data are analysed and interpreted independently by separate contractors. It is difficult for lifestyle and some family farmers to comply with the new surveillance regulations and technology, and as a consequence, some struggle. Among the limitations of this export-oriented model of surveillance (which is concerned with detection of notifiable diseases and AMR) is that endemic non-notifiable diseases spread relatively freely. There are frequent disease outbreak scares, which stem from the importance of the livestock industry to Scotland and the open nature of surveillance data. These frequent alarms result in market volatility. Due to AMR, antimicrobials are strongly regulated, but there is a black market in pharmaceuticals.

Could This Scenario Happen? A Plausible Road Map

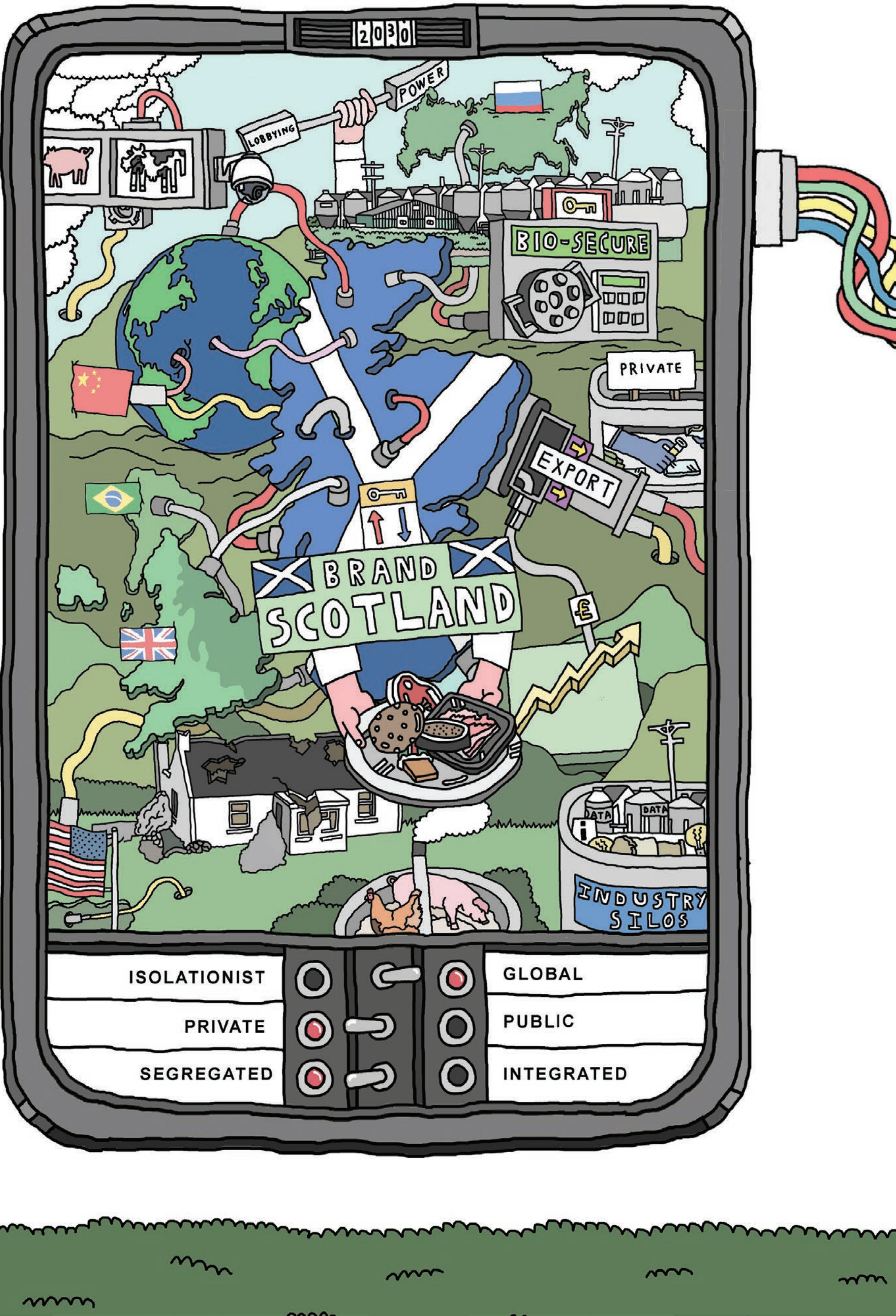
The global appetite for strong livestock health and disease surveillance was prompted by a pandemic antimicrobial-resistant disease outbreak, which was thought to have origins in the livestock sector. The consequence of this scare was the recognition of a need for tight regulation of the use of veterinary pharmaceuticals, and for traceability of livestock produce. In order to support a rationale for enhanced testing of livestock for pathogens, many bacterial pathogens were made notifiable. In post-Brexit, independent Scotland, trade rules were dictated by World Trade Organisation (WTO)-type regulations and bilateral standards were agreed regarding freedom from disease and traceability. Scotland recognised its need to respond to align its surveillance activities, in order to take advantage of global demand for well-sourced and traceable livestock products, as well as the high price that can be demanded for such products. To fund this, the government invested in surveillance structures and funded testing and wider surveillance activities through independent contractors. This was accompanied by a large investment in R&D to develop the new surveillance technologies. As a result of these activities, the Scottish brand became very desirable.

There was some regulation to accompany this to ensure that all surveillance data were made publicly available. One downside of this was that there were a number of "false-alarms" over disease outbreaks: many individuals were analysing these data, and a high number of false positives were generated. Following the AMR scare, the surveillance technology was high-tech but its adoption disproportionately benefitted the larger and more professional farms and as a consequence, smaller and family farms struggled to remain in business. Surveillance increasingly focused on the use of antimicrobials and exotic notifiable diseases. Endemic, non-notifiable diseases were considered less important and early detection and control was largely neglected. These diseases remain the business of "traditional" general veterinarians, but these vets have been declining in number.

Opportunities	Challenges
Robust tech market and diagnostics and research sectors This improves competition for contractors and suppliers for the booming veterinary surveillance sector, which improves overall performance	The agricultural industry is vulnerable to shifts in political will Poor data-handling and communication skills: misuse or misinterpretation of large amounts of available data The sometimes expensive and complicated technology requirements create a squeeze on small farms, crofters, which struggle to comply with regulations and adopt the technologies Limited broadband access in remote areas Disease detection for non-notifiable diseases is neglected



Scenario 5: Market Farm



The Future

Farming is dominated by those willing to embrace efficiency and innovation. Farming has become increasingly siloed (i.e. within an industry sector or a large vertically-integrated retailer). Sectors specialising in high-value areas (such as high genetic-value beef production), become very successful and others (such as the pig and poultry sectors) that are already relatively isolated (and in silos), accustomed to less support and able to build on international links are able to continue much unchanged. Trade is important, particularly exports, and this drives much of animal health surveillance. Large farms invest in high standards of biosecurity to ensure they are not affected by disease threats associated with smaller farms. Corporate farms and supermarkets have strong lobbying power and industry protects the interests of these members. As a result, smaller farms gradually fall out of the system and are not well served. Although Scotland is still part of the UK, "Brand Scotland" is key in developing and promoting trade. R&D is driven by industry, and conducted in private institutes, often linked to existing universities.

Surveillance

In this future, data are a commodity. Surveillance within silos is generally good, vertically integrated, and aimed at the diseases of highest importance to the sector, either for trade purposes, or production diseases. Data are not shared outside of individual silos. Emerging diseases can be detected quickly, provided that detection is not dependent upon detection of a pattern across multiple silos. The only data that are likely to be shared by industry are those that increase the product value, i.e. those that are subject to consumer pressure, which might include information on antibiotic resistance and welfare-related issues. This industry-driven surveillance, which accounts for the majority of surveillance in place, is privately funded and utilises private laboratories. The government funds approximately 20% of the surveillance budget, and operates a much reduced laboratory system. Government's main role is in statutory disease reporting for the World Organisation for Animal Health (OIE) to maintain global trade, for which they collate data provided and paid for by the industry. Industry data are only shared with government as required on a statutory basis to fulfill these obligations. Government is also responsible for surveillance relating to public health, and wildlife surveillance that is required to meet statutory/trade requirements. Surveillance in smaller or backyard farms is almost non-existent.

Could This Scenario Happen? A Plausible Road Map

After 2020, following Brexit and in line with a general direction of austerity, the CAP system was dismantled. Production subsidies declined, although environmental stewardship schemes increased. To be successful, companies or sectors had to be efficient to compete, meaning that over the next ten years, farms and herds got larger. In the absence of other support, the funding schemes that came into place at this time were aimed predominantly at innovation. These focussed on three areas: support for new entrants, near-market R&D and translational research. Fiscal policy changes made it easier for new entrants and encouraged entrepreneurship. The push for technology funding meant that technology uptake was high, and both large efficient farms and new entrants embraced technological innovation. The drive for industry, efficiency and innovation meant that the success of individual sectors depended on their ability to capitalise on international selling points. By 2025, one of the winners in this system was "Brand Scotland" beef production, with Scotland becoming a breeder base for high genetic value beef. Increasingly, producers imported and exported genetic material rather than live animals. In the absence of support from government, farmers paid for the surveillance required for trade. In parallel, after 2020, austerity and a lack of government investment in surveillance meant the veterinary laboratory structure in Scotland was gradually reduced. A series of high profile exposés based on freedom of information requests generated a climate of suspicion about data sharing with government. Together this accelerated a general trend towards industry-driven and industry-funded surveillance.

Opportunities	Challenges
The number of agri-businesses has decreased, as size has increased, so there are fewer data "silos". Data are obtainable if this can be negotiated between industry partners "Brand Scotland" is strong	There is a systematic lack of detection of novel diseases due to data silos There is limited state access to animal (livestock, companion and wildlife), human and environmental data to give a holistic surveillance picture There is a loss of farming heritage, skills and institutional memory about disease, as well as marginalisation of small farms

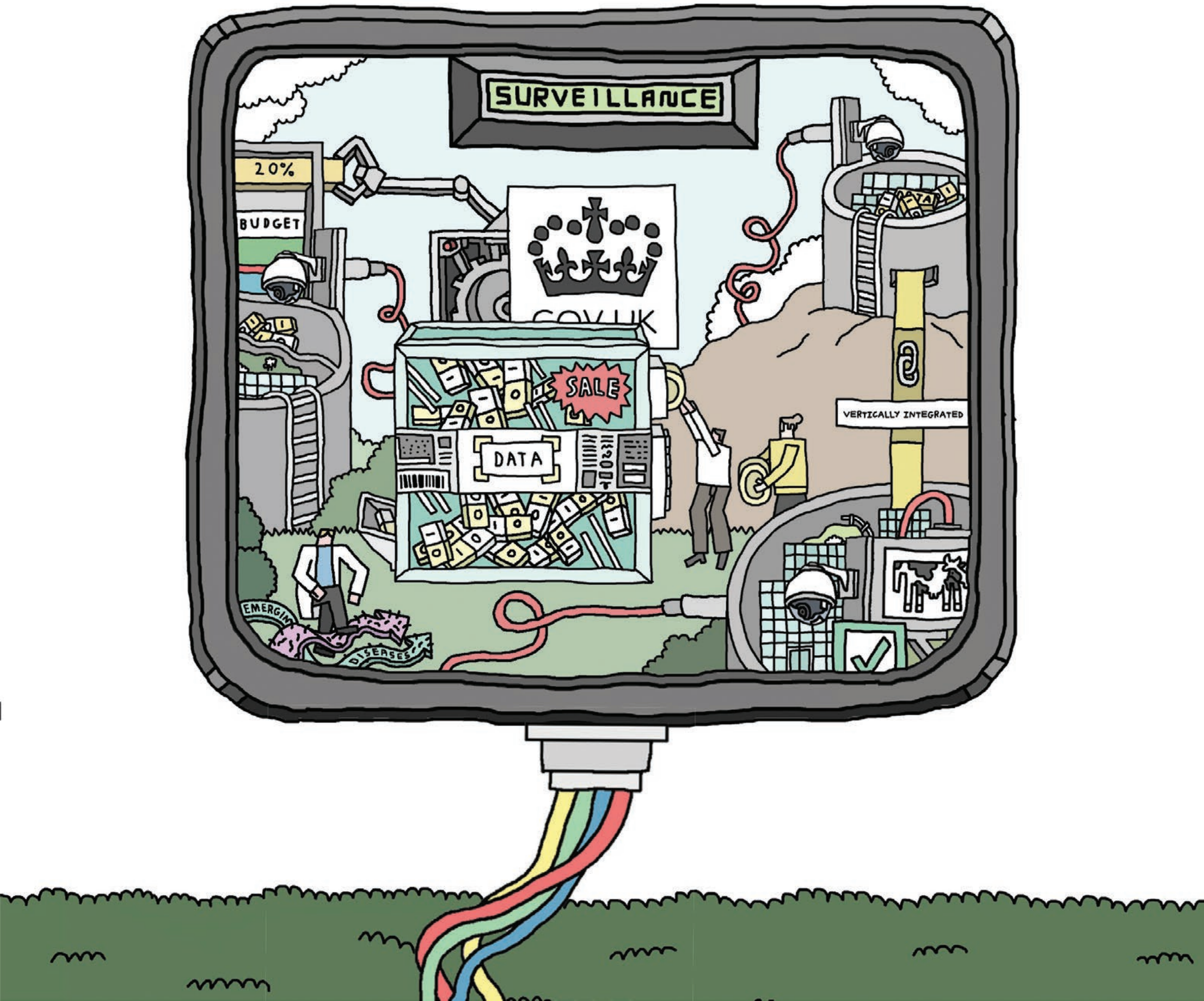


Table 2. A Cross-comparison of 2030 Futures

	Scotland Alone	Oceania	Free Fall	Global Farm	Market Farm
Animal numbers Livestock: cattle, sheep, pigs and poultry Horses, companion animals and exotic pets were not considered in detail in any of these futures	Decreased numbers of livestock populations compared to 2017	Decreased numbers of pigs, poultry Stabilised numbers of sheep and cattle	Decreased numbers of cattle, sheep and pigs relative to 2017, but a stable poultry population	Decreased numbers of livestock populations compared to 2017	Decreased sheep and cattle. Increasing herd sizes Increased numbers in pig and poultry sectors
Farm and farmer demographics	Bifurcation in farm size: fewer farms overall, more large farms, and more new entrants with very small holdings	Increase in farm size Fewer small farms MNCs leave	Increase in size and number of commercial operations Decrease in lifestyle farmers Few new entrants	Increase in commercial farm size Decrease in numbers of lifestyle farmers	Increased numbers and size of commercial farms. New entrants increase Lifestyle farmers have gone. Small holders remain but are very distinct from commercial farms
Imports	Decreased Black markets emerge	Decreased Change in trading partners	Decreased EU imports Change in trading partners	Decreased	Increased
Exports	Decreased	Niche market Decreased exports	Niche market Decreased exports	Increased Brand Scotland in demand	Increased Brand Scotland in demand
Exotic Disease	Decreased	Decreased	Increased	Decreased	Decreased
Endemic Disease	Increased	Decreased	Increased	Increased	Decreased

Table 2 contd. A Cross-comparison of 2030 Futures					
	Scotland Alone	Oceania	Free Fall	Global Farm	Market Farm
Pharmaceutical regulations	High regulations among commercial farms Little use of pharmaceuticals among small farms	Reduced regulations	Reduced regulations	High regulations Black markets	Reduced regulations
Surveillance funding	Private (individual farmer) funding	Public funding	Public funding declining Industry-led funding increasing	Public funding implemented by private contractors	Industry funding
Technology	Reduced investment Use available, cheap technology Low uptake by small scale farmers	Increased investment in R&D for tools to aid on-farm diagnosis Government-led so uptake high	Increased investment in R&D for tools to aid on-farm diagnosis Mixed uptake depending on sector and farm-type	Increased investment in R&D for tools to aid on-farm diagnosis Mandatory uptake	Reduced public investment Private investment increases R&D High uptake
Data collection and sharing	Reduced volumes of data Data are not shared	Large volumes of real time state owned animal health and disease data Data are widely shared	Outbreak response data only Some data sharing	Large volumes of data Data are shared	Large volumes of high quality data within each business Data are not shared
Veterinary Infrastructure	Fewer vets	Increased state veterinary service and additional research capacity Fewer vets in rural areas and in general practice	Fewer vets in rural areas and in general practice	Greater number of specialists Fewer vets in general practice	Reduced numbers of state vets Increased in-house industry vets
Anti-microbial resistance monitoring and prevalence	No national monitoring or reporting of AMR in agriculture	National monitoring	National monitoring in some sectors	National monitoring	No national monitoring or reporting of AMR in agriculture

Strategies to Improve Resilience

Creating Strategies

The potential opportunities and challenges identified for each scenario provide an opportunity to consider how these might be exploited or mitigated. Participants devised a set of strategies that could be initiated in the present day, to mitigate future risks or exploit opportunities in the sheep industry relating to disease. Strategies considered desirable and effective in one scenario can be irrelevant or even counterproductive under a different set of circumstances that might plausibly emerge.

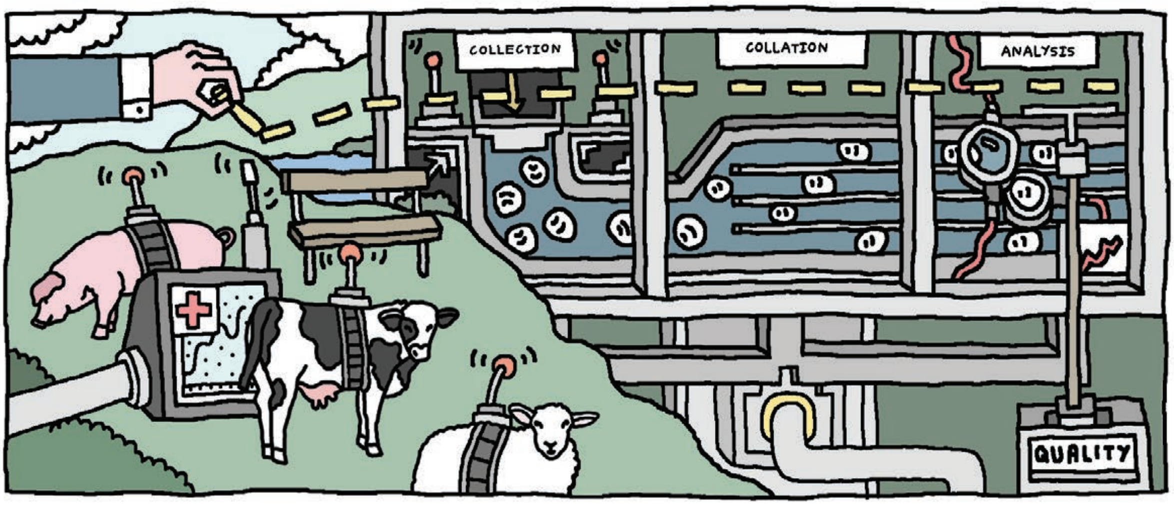
We examined participant-proposed strategies for resilience in the context of the five scenarios and analysed their strengths and weaknesses. Ten independent and unique surveillance strategies are described below and are summarised in Table 3. Information is also provided about the additional resources required to implement these to ensure the strategy is a successful and sustainable long-term investment.

1. Industry Best

This is a "benchmarking" scheme that facilitates the collection, collation and analysis of data on healthy animals (through multi-pathogen screening, biomarkers and other sensors detecting animal movement patterns, behaviour etc.). In order to be sustainable in the long-term, this strategy will require concurrent investment in infrastructure to collect and communicate data and availability of cheap, reliable technology.

Gaps in resilience: This strategy addresses a gap in the collection and sharing of data regarding the long-term variability of health status of individual animals/herds/farms (e.g. Scotland Alone, and to a lesser extent Market Farm). This strategy will maximise existing opportunities in futures where data are already freely available and widely shared (e.g. Oceania) and/or there is available technology to collect on-farm data (e.g. Free Fall, Global Farm).

Signals supporting implementation: Increased prevalence and uptake of monitoring sensors and other technology to capture data on farm.



2. Health Risk States Scheme (HRSS)

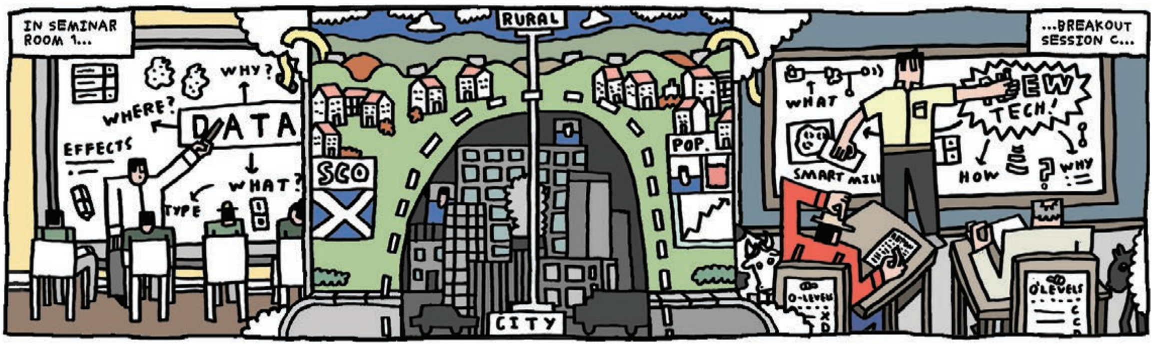
This strategy introduces legislation to enhance surveillance for novel and emerging diseases through statutory reporting of "health risk states" i.e. conditions that are not notifiable, but which may pose a significant risk to public or animal health. HRSS reporting is a system currently used in human health and ensures potential threats are flagged based on clinical signs and epidemiology, even if the causative agent is not known. This may benefit from co-localisation of and resource sharing between veterinary and human health laboratories.

Gaps in resilience: This strategy addresses gaps in surveillance data, particularly in futures where clinical submissions are low, and there is a high, unmitigated risk of emerging or novel disease threats. It could be particularly valuable in futures where data are held by commercial companies, by essentially legislating sharing of early warning signs and promoting syndromic surveillance (e.g. Market Farm, Free Fall). It would be of limited value in state-run futures where there are already systems in place to manage and analyse data (e.g. Oceania, Global Farm) or where there is low demand for data and a dearth of expertise to analyse it (e.g. Scotland Alone).

Signals supporting implementation: Decline in participation in active surveillance programmes. Routine daily data collection of health data is implemented by many farms.

3. Digital Farming Families

This is a targeted, grant-funded data-skills training scheme for farming families in rural areas in Scotland to provide digital literacy education at all levels, with a specific application of such skills to farming needs. This will enable successive generations of farmers to be prepared for technological changes as they occur. This is contingent on R&D funding and research innovation to ensure there are technologies available for precision agriculture. The demand for precision agriculture and disease detection may also depend on international standards for trade risks and non-tariff barriers to trade.



Gaps in resilience: This strategy addresses gaps in agricultural data analysis, digital literacy in farming data informatics (for all ages) and technological expertise. It will work best in futures where there are clear farming legacies and succession planning for the next generation of farmers. There are obvious benefits in any future where there is a knowledge gap between technology and end-users, a lack of buy-in to any informatics strategy from the farming community and a need for skilled expertise (e.g. Global Farm, Oceania, Free Fall). It is of less value in futures, where there is a low demand for technology (either because of availability, affordability or perceived benefits) (e.g. Scotland Alone). It may be less relevant in futures, which are dominated by large agri-businesses which already have access to this training and expertise (e.g. Market Farm).

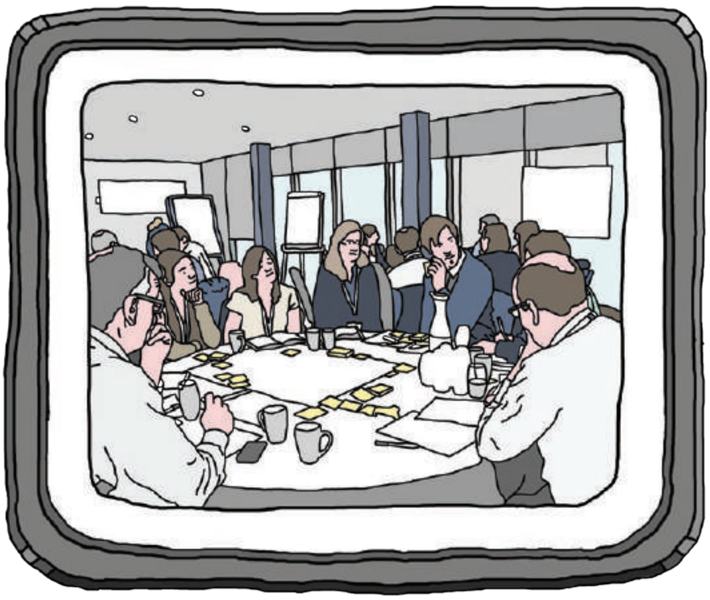
Signals supporting implementation: Increased volumes of "Big Data" routinely collected from significant numbers of competitive farm businesses; significant shifts in farming demographics (indicating a decline in traditional family farms).

4. Flock-Book

This is a social media platform for farmers to enable transparent data sharing, communication and analysis of animal surveillance data (particularly for non-notifiable diseases). This platform will be underpinned by algorithms that process and analyse data as they are entered and, if desirable, could trigger automatic screening. This system is farmer-owned and led. There are opportunities for this to be a commercial business, generating income for farmers through online advertising. It is necessarily underpinned by R&D investment to develop new technologies and data analytics and requires broadband connectivity to work.

Gaps in resilience: This strategy addresses a gap in knowledge, communication and real-time data analysis. It will work well in futures where farmers need to empower industry and improve solidarity and increase opportunities for early warning systems and reduce time-to-detection (e.g. Scotland Alone, Free Fall, Global Farm). It could be particularly useful in futures with strong social-media information-driven criticism. It will be redundant in futures where demand for infrastructure and training is already addressed by market forces (e.g. Market Farm) or government (e.g. Oceania).

Signals supporting implementation: This strategy might be triggered by a significant shift in population demographics and a drop in research investment which would reduce data analytic support and place greater demands on clinicians, farmers and agricultural workers to do this work.



5. Scotland's Mobile Abattoir Scheme

This is an investment to bring surveillance to the farmer. It provides an opportunity to turn traditionally passive surveillance techniques into active surveillance programmes. This scheme will enable on-farm slaughter along-side real-time clinical sampling and robust field-testing to enable rapid detection of endemic and production-limiting disease: information which can be fed back directly to the farmer for his/her benefit. It will also potentially generate data to improve farmer detection of emerging or exotic diseases. In order to be feasible, this scheme needs to be supported by concurrent investment in laboratory capacity, data management infrastructure and technological innovation (pen-side testing) to capture and utilise these data efficiently. Education and training for farmers, vets and para-vet technicians to improve vigilance is also an essential precursor.

Gaps in resilience: Provided that farmers can afford the necessary human and technical infrastructure, this strategy will mitigate gaps in data collection and farmer participation in surveillance systems. It will improve the resilience of clinical data collection in futures which are characterised by geographically remote and disparate populations of farmers (e.g. subsistence farms in Scotland Alone). It may also be a reasonably useful strategy in futures where there are poor rates of sample submissions due to reductions in veterinary surveillance capacity or where endemic disease is an increasing burden on production efficiency (e.g. Free Fall or Oceania to a lesser extent). Indirectly, the strategy could also have welfare benefits by reducing travel to abattoirs and it could be augmented by implementation of complementary telemedicine (or tele-surveillance) approaches. It is of less use in futures where there are agri-businesses with high stocking rates, which will require more substantial abattoir facilities to accommodate throughput (e.g. Market Farm) or already strong surveillance systems in place with mandatory participation and/or high investment in R&D (e.g. Oceania, Global Farm) which permit rapid on-farm diagnoses. This strategy may be unsustainable in futures where funding is scarce, due to necessarily high set-up and running costs (for example, in Scotland Alone, the subsistence farmers who would most benefit are those least able to afford it).

Signals supporting implementation: Significant shifts in farmer demographics and a downturn in submission rates to existing surveillance programmes.

6. Surveillance Data Agency

This is a non-profit, independent, cross-sector (animal, human, plant, environment) health data “gate keeper” which promotes data sharing. The agency is designed to decouple surveillance data from cross-compliance, and to demonstrate the benefits of a multi-disciplinary partnership approach to animal health surveillance. This strategy would be underpinned by a coherent long-term data strategy focused on support of epidemiological objectives. Partners from agriculture, environment, wildlife, water etc. pay a nominal fee and consent to provide data in order to participate in the scheme and share and analyse all other available data. Technology must be available and accessible to collect appropriate high resolution human, animal and environmental health data. Telecommunications infrastructure needs to be in place to be able to share it.

Gaps in resilience: This strategy addresses gaps in data sharing and lack of control and/or non-compliance by industry. This is not government-led so it enables data use to be decoupled from issues of cross-compliance. Data are a commodity - this strategy will work best in futures where there are incentives to participate to gain access to data (e.g. futures in which data are segregated- e.g. Market Farm, Free Fall), but it may also empower stakeholders with alternative choices, in futures where government control is strong (e.g. Oceania and it could be of particular value if state-directed sources of surveillance data only focus on exotic notifiable diseases (e.g. Global Farm). It is of limited value if technologies to collect data are not cheap, robust or readily adopted by farmers (e.g. Scotland Alone). Additionally, there could be teething problems if businesses perceive a loss in competitive advantage if they participate in the scheme.

Signals supporting implementation: Increased volumes of "Big Data" routinely collected from significant numbers of competitive farm businesses.

7. Rural Vet Scheme

This is an incentive strategy to attract to and retain expertise in Scotland. It includes education bursaries or grants to attract vets to large animal practice in rural areas. It also includes incentives for farmers to utilise these veterinarians to ensure there is adequate demand for the services. In order to be feasible, it requires private or public sources of funding.

Gaps in resilience: This scheme will mitigate gaps in futures where there is limited veterinary expertise in remote rural areas (e.g. Free Fall and to a lesser extent, Global Farm and Scotland Alone). However, there is limited value in futures where the career-path for veterinarians is predominantly within government (e.g. Oceania) or in industry (e.g. Market Farm).

Signals supporting implementation: Significant decline in numbers of veterinarians going into livestock practice (in vet school) and ending up in practice in rural areas in Scotland.

8. Science-Policy-Industry interface Networks for Disease Exposure and Control (SPIN-DEC)

This is a strategy to anticipate and counteract "fake news" and empower and arm vets, farmers, agricultural sector, public health stakeholders, retailers and supermarkets with expertise and intelligence. International trade of animals, animal-by-products and food is an important precursor.

Gaps in resilience: This knowledge network addresses gaps in industry solidarity and evidence-based policy alongside erosion of consumer trust, due, for example, to "fake news". This strategy will add value in futures where the veterinary services are run and funded by the state, making them vulnerable to reprioritisation (e.g. Oceania) and/or futures where mitigating the risks of animal disease outbreaks is critical to protect the Scottish Brand (e.g. Free Fall, Global Farm). This will be important if there is a focus on trade-driven disease control. It will be less useful in futures where is no need for an evidence-base to underpin policies on trade or animal health and welfare either because trade is limited (e.g. Scotland Alone) or industry is already an influential lobbyist (e.g. Market Farm).

Signals supporting implementation: Significant political shifts which affect market volatility; shifts in public perception and trust in expert opinion.

9. Animal Data Levy

This is a new revenue stream funded through public-private partnerships, established to ensure that data are accessible and to increase industry participation in surveillance. This may include a levy charge for industries, which buys them access to data. It requires cooperation and collaboration between funders and the decision makers. Investors need to see the benefits of funding and access to data.

Gaps in resilience: This strategy addresses gaps in surveillance funding and ensures data are accessible to industry as well as government. It will work well in futures where there is a need to mitigate the effects of data being held in silos (e.g. Free Fall, Market Farm), but will be limited if the “industry” is not economically viable or there is no industry solidarity (e.g. Scotland Alone). It may be unnecessary in futures where data are already publicly-funded and freely shared (e.g. Oceania, Global Farm). Public-private partnerships may be likely to improve “One Health” approaches to healthcare and contingency planning and would be feasible and effective if implemented. However, if companies are forced to share all of their data as a condition to access, there may be some resistance to uptake in this future (e.g. Market Farm).

Signals supporting implementation: Public funding cuts for disease surveillance in the face of ongoing or emerging disease threats.

10. Disease Intelligence Squads

This strategy creates teams of veterinarians, para-vets, technicians and nurses who are trained to improve real-time, high quality data collection and analysis and respond to early warning signals. The feasibility and sustainability of this strategy is contingent on the collection and sharing of high quality longitudinal data on both healthy and diseased animals to identify thresholds for early detection and intervention at pre-clinical or clinical stages. Other necessary precursors include centralisation of data collection and essential, appropriate training to ensure there is expertise to distinguish noise from important signals in the data.

Gaps in resilience: This strategy addresses gaps in real-time data analysis and response to disease control (e.g. Oceania). It will work well in futures where there are already strong veterinary services, and high tech diagnostic options for on-farm data collection (e.g. Free Fall, Global Farm). It will be of very little value in futures where data collection is limited or data are commercially sensitive, disease control is unfeasible or unaffordable or where there is limited expertise or few trained personnel available to police numerous small-holdings (e.g. Scotland Alone). It is redundant in futures where similar in-house expertise is already in place and/or data are too commercially sensitive to share (e.g. Market Farm, Scotland Alone).

Signals supporting implementation: Increased volumes of “Big Data” routinely collected from significant numbers of competitive farm businesses.

Table 3. A Cross-Comparison of Strategies to Improve the Future Resilience of Animal Health Surveillance in Each Uncertain Future

Strategy / Future	Scotland Alone	Oceania	Free Fall	Global Farm	Market Farm
Industry Best	High	High	High	High	Medium
Health Risk States Scheme	Low	Medium	High	Medium	High
Digital Farming Families	Low	High	High	High	Low
Flock-Book	High	Low	Medium	High	Very Low
Scottish Mobile Abattoir Scheme	Medium	Low	Medium	Low	Low
Surveillance Data Agency	Very Low	Medium	High	Medium	High
Rural Vet Scheme	Medium	Low	High	Medium	Very Low
SPIN-DEC	Very Low	High	High	High	Low
Animal Data Levy	Very Low	Low	High	Low	Medium
Disease Intelligence Squads	Negligible	High	High	High	Negligible

Very High	Always highly practical, relevant and cost-effective
High	Mostly practical, relevant and cost-effective
Medium	Often practical, relevant and/or cost-effective
Low	Sometimes practical, relevant and/or cost-effective
Very Low	Not often practical, relevant and/or cost-effective
Negligible	Never practical, relevant and/or cost-effective

Discussion

The EPIC scenario planning workshop produced five plausible and diverse views of the future of Scottish animal health surveillance. These scenarios highlight a number of important and influential factors (drivers) that have the capacity to affect long-term resiliency of early disease detection and control of exotic, endemic and novel animal and zoonotic diseases. These drivers include: international trade policy, data access and sharing philosophies and sources of financing for surveillance infrastructure and capacity.

The process of creating these scenarios first required consideration of what the livestock industries might look like in a future Scotland, including factors such as farming structure and demographics, farming education and technology uptake. Future resilience planning for the cattle and sheep industries has been addressed in detail in previous foresighting work (Boden et al. 2015, EPIC 2014a, 2014b) and some of the findings in this report echoed these earlier workshops. Consideration of industry structure was necessary to enable a subsequent exploration of the requirements, structure and limitations of surveillance in each scenario.

The results of the scenario planning work suggest that a strong "Scottish brand" should be encouraged, driven by industry self-sufficiency and solidarity (through improved telecommunication, data sharing and delivery of veterinary surveillance services, particularly in remote areas in Scotland). These investments were considered vitally important, irrespective of whether Scotland has an isolationist or globalist outlook on trade and were thought necessary to ensure that future demographic changes in production systems don't result in fragmentation of disease expertise and vigilance. These findings were similar to those in previous scenario planning activities (Boden et al. 2015) which also indicated a plausible future shift towards more efficient large-scale commercial businesses and/or very small-scale, backyard farming or a polarised situation including both. In this workshop, participants thought that the lifestyle or family farmer might disappear completely from most of these futures, raising important questions about succession planning and the value placed on the family-farm as part of the heritage of Scottish society. The balance of global versus isolationist trade also drove the type of surveillance. Scenarios exploring futures with strong international trade policies had surveillance systems focused predominantly on diseases important to trade, whether driven by industry (Market Farm) or by government (Global Farm), with gaps in surveillance in other areas.

At the time of the workshop, the UK government's position on conditions for leaving the EU was not known. The effect of this unexpected "shock" event was assessed by some participants as having dominated scenario discussions, and as a result, perhaps restricted deeper discussion of genuinely impactful, but less immediately salient drivers, including those whose own uncertainty has been radically increased by Brexit. It may be usefully contrasted with discussions in previous scenario planning workshops (EPIC 2014a and b) on the future of specific livestock sectors in Scotland, where the then pending referendum on Scottish Independence did not dominate the discussions. The project team would retrospectively suggest that this may have been because the UK was seen a priori as a single epidemiological unit, and also that as Scotland and the rest of the UK would both remain within the European Single Market come what may, commercial and governmental policies would have to operate within these constraints. Hence, independence was seen as having little impact on the evolution of the sector because of epidemiological and political constraints.

Overall, participants felt that Brexit may have negative impacts on attracting and keeping researchers with animal and zoonotic health surveillance expertise to Scotland and the UK. Other implications of Brexit were discussed, including changes to pharmaceutical regulatory structures, which may consequently influence R&D investment, access to other types of research expertise, medicines and new diagnostics. AMR, which today is considered one of the greatest threats to human and animal health, was surprisingly not considered in depth in every future during the workshop. However, in some futures (e.g. Scotland Alone, Market Farm), it is logical that AMR prevalence would remain unknowable and a threat to human and animal health if gaps in data sharing and data silos are not addressed before 2030.

The type and logistics of surveillance were driven in many ways by the source of the funding to support it. Scenarios where government funding persisted allowed more targeted industry-wide surveillance, such as AMR detection. Those where surveillance was industry-led and funded had advantages of better surveillance within vertically integrated systems "from farm to fork", and of organised sectors prioritising control of diseases important to the industry. However they left potential gaps in wildlife, public health, emerging disease and potentially endemic disease surveillance, raising questions over where a limited government budget was best deployed. Several strategies, such as public-private partnerships or incentivised data sharing schemes, were aimed at mitigating the issues of industry-led surveillance that may not promote data sharing or public health; R&D spending to translate research into innovation was an important precursor for effective surveillance strategies in any future.

Holistic surveillance was challenging when data were a commodity shared only within commercial companies. The impact of this within the scenarios is reflected in the number of the strategies aimed at either trying to prevent this situation emerging, such as strategies to demonstrate the benefits of data sharing as soon as possible, or at mitigating the effects of closed data policies, such as incentivising or legislating sharing of information. Scenarios with integrated data policies, although they had advantages for surveillance, highlighted potential risks of false alarms associated with data misuse, and the roles of social media and public opinion.

Limitations

The original intention of this workshop was to include a consideration of disease surveillance in equidae, wildlife and companion animals. However, these sectors did not feature strongly in any future described. This was likely attributable to the composition of the workshop participants (and subsequent small group dynamics) who used the limited time for discussion to focus primarily on impacts of surveillance on livestock farmers rather than equine and companion animal owners. Participant diversity, the time available for discussion, and the particularity of contextualised data elicited from discursive approaches are limitations of a scenario planning approach (Wodak and Meyer 2009). Nevertheless, EPIC's opinion is that there would be value in holding a separate, similar workshop to identify issues for future surveillance in these sectors if some of the lessons learned from this study are not easily transferrable.

Scenario planning is not a traditional methodology used within the epidemiological research field. It is challenging for participants to consider non-probabilistic "what-if" scenarios rather than considering desirable or probable futures. However, this method is deliberately designed to allow participants to consider creative, alternative strategies, which might be useful in any future that might occur. In practice, each of the ten strategies proposed by participants (and developed by EPIC scientists) will vary with respect to its cost-effectiveness and feasibility in different uncertain futures. The results from this workshop suggest that a benchmarking scheme, (such as Industry Best) is most likely to be beneficial across different futures. This is followed by strategies to introduce legislation to enhance surveillance for novel and emerging diseases through statutory reporting of "health risk states" (such as the Health Risk States Scheme) and grant-funded data-skills training schemes (such as Digital Farming Families). The results of this workshop have also made it possible to consolidate five important criteria which may in combination, indicate the increasing likelihood of one future over another and highlight the value of scenarios as tools to improve decision-making about which strategies (generated here or in future discussions) make the best investment for the long-term. These are described on the next page and are broadly encompassed by shifts in: farmer demographics, technology uptake, attitudes towards data commoditisation, surveillance submission rates by currently available routes and significant political shifts and public perceptions about evidence.

Signals Supporting Investment in One or More Strategies

Significant shifts in farmer and veterinary expertise and demographics

Road to futures: Scotland Alone, Market Farm and Free Fall

A decline in the number of traditional, family-run farms, consolidation of more profitable businesses into big agribusinesses and an increase in the numbers of backyard keepers, who may or may not have good knowledge or expertise about animal health and welfare

Increased uptake by farmers of technology

Road to futures: Oceania, Global Farm, Market Farm

This includes cheap available telecommunications and "smart" systems, sensing technology, point-of-care diagnostics and data management tools which will enable large-scale high resolution data capture and analysis on-farm

Increased perception of data as a commodity and availability of 'Big Data'

Road to futures: Oceania, Global Farm, Market Farm

This includes data on animal, human and plant health and disease and the environment. This may result in new inequalities defined by data "haves" and "have-nots"

Decline in surveillance submission rates by current routes

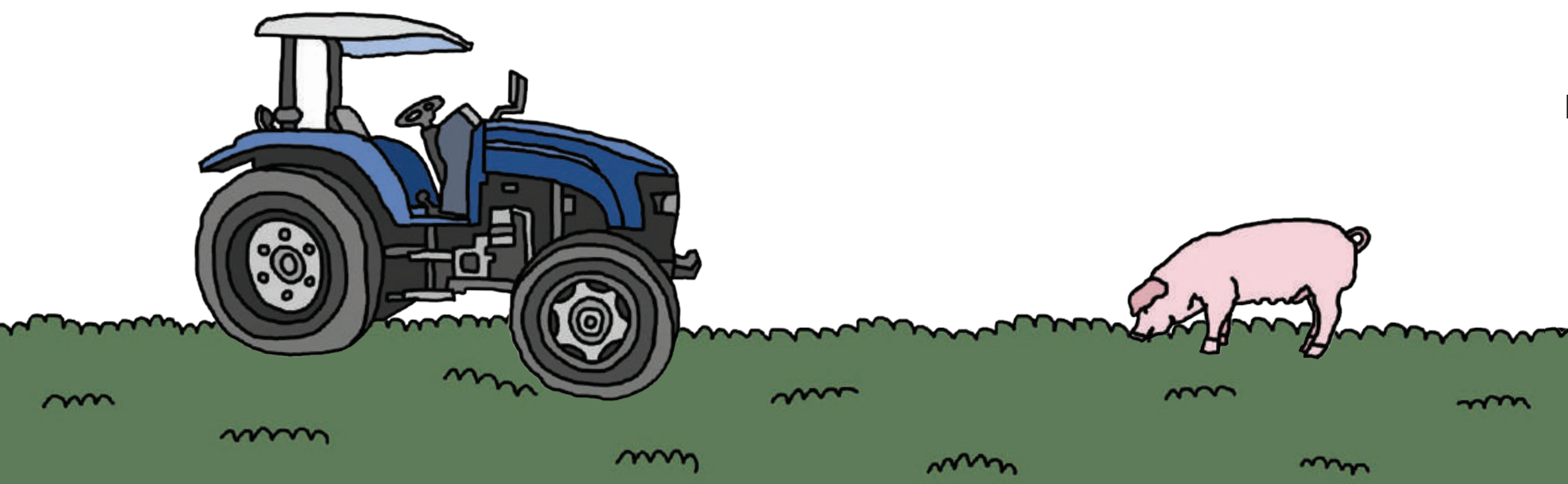
Road to futures: Scotland Alone, Free Fall

This includes clinical samples to laboratories as part of surveillance programmes and/or decline in call-outs to veterinary practices

Significant political shifts and changes in public perceptions about evidence

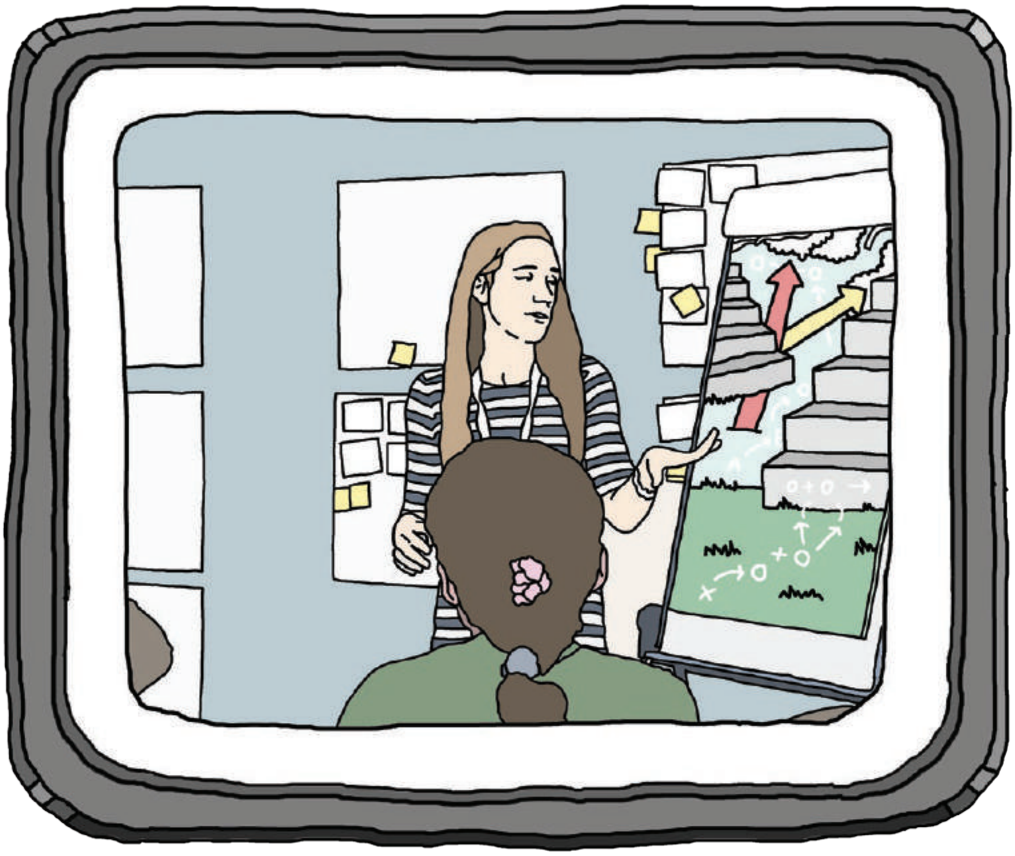
Road to futures: Oceania, Global Farm

This is due to "democratisation" of data and erosion of trust in expert opinion



Next Steps

Scenario planning enables a process of dialogue at the interface between science, society and policy and should have a positive impact at both the policy level where stakeholder buy-in and input are advantageous, and at the local industry level where innovation and good practice will be encouraged. This reflexive approach is not just about improving anticipatory governance but rather, emphasising the promotion of parallel partnerships between governance and society in the face of uncertainty to improve the future (Laurie 2011, Boden et al. 2015). We hope the results of the current study will create new opportunities for dialogue about the robustness and long term future of Scottish animal health surveillance. These results will be made available to workshop participants as part of a consultation process. They will subsequently be shared with relevant stakeholder and policy groups, including the British Veterinary Association Surveillance Working Group and the Scottish Government Strategic Management Board for Veterinary Surveillance.



Further Reading

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Appendix

1940s and 1950s: "War, then Peace"

British society was strongly influenced by the legacy of the Second World War. There was low unemployment and many workers were trade unionists. However, strikes were illegal until 1951 and the Labour government took strong action to prevent interference with food supplies and exports. Taxation was high and there was ongoing (and in fact, sometimes increasing) rationing of some essential supplies, including bread, eggs, milk, butter, cheese, meat, sugar and petrol. A housing crisis meant there was increasing expansion of urban footprints throughout the period. However, most of the UK land mass was still rural and farming was extensive in nature. The use of hedgerows and absence of chemical use supported high biodiversity of birds, insects and wildlife. The 1947 Agricultural Act subsidised farmers' incomes via guaranteed prices, and the numbers of agricultural workers were at an all-time peak, boosted by conscription into the Women's Land Army. However, many rural residents were still living in poverty, many without electricity. Rural areas were also at great risk from severe weather events, including serious flooding (e.g. East Anglia in 1953). The UK population (~50 million) was predominantly of British ethnicity.

The majority of immigrants were Irish and white Europeans (including Jewish refugees escaping the Holocaust), while Commonwealth citizens had unrestricted access to the UK (1948 British Nationality Act). The creation of the National Health Service (1948) meant that the availability and quality of medical care improved for most people. This was the golden era of microbiology and the introduction of antibiotics eradicated many diseases including human tuberculosis (TB), even if antibiotic resistance also soon developed. Polio outbreaks were common until vaccines were developed in the 1950s. The ethics of conducting clinical trials or experimental studies was not yet a matter of importance. Epidemiology was becoming more widely appreciated, including in the veterinary sector, with large-scale population-based studies undertaken to explore causes of disease and wastage in the dairy industry. By the end of this period, the Sputnik satellite (the necessary precursor of GPS) was orbiting the earth, the first drones were being planned by the USAF, and the first nuclear power stations had come on-line in the UK.

Surveillance

The first Veterinary Investigation Centre had been set up in Wales in 1922, and was attached to a local agricultural college. After the war, VI Centres in England and Wales came under the control of the Central Veterinary Laboratory (CVL) in Weybridge, forming the Veterinary Investigation Service. The CVL had been set up to control an outbreak of swine fever (pre 1900) and it then became part of the Ministry of Agriculture Fisheries and Food (MAFF). A post-war outbreak of Foot-and-Mouth disease (FMD) in 1952 led to a major expansion in facilities for virus research at the Pirbright Institute. The UK State Veterinary Service was well-prepared for outbreaks during this time. FMD outbreaks were reasonably common, with the Gowers committee noting in 1954 that there had been no single year between 1929 and 1953 in which the UK had been FMD free. Compulsory TB testing was introduced in the 1950s. In Scotland the three colleges of agriculture (East, North and West of Scotland) initially established Veterinary Investigation Centres in Edinburgh, Aberdeen and Ayr respectively to "provide advisory consultancy and diagnostic services on farm animal diseases and to support the colleges' activities in education, …research and development" (Kinnaird Report 2011). By the end of the 1950s, there were also Veterinary Investigation (VI) Centres in Inverness, Oban and Perth.

1960s and 1970s: "Breaking with Tradition"

By the 1960s, the first generation of Britons not subject to conscription emerged into society, resulting in an increased emphasis of freedom, fun and experimentation. More of the public began to question authority and feminism became a more influential ideology; the death penalty was abolished, homosexuality and abortion were legalised and theatrical censorship was abolished. Social mobility increased as more jobs became available, and the Equal Pay Act, Sex Discrimination Act, Race Relations Act and other legislation helped promote and enforce equality. The UK population was increasing, but this was predominantly in urban areas and the numbers of agricultural workers declined dramatically. Technological advances in transistor-based electronics such as the television, computer and Neil Armstrong's moon landing heralded decades of rapid technological innovation: "the white-heat of technology". During this period the first packet switching networks were developed, and the first email was sent. Biodiversity had decreased with the use of synthetic pesticides like DDT, and the publication of Rachel Carson's book "The Silent Spring" inspired the beginning of an environmental movement.

More people began to travel, using a growing motorway network and the advent of cheaper and faster air travel including the maiden Concorde flight. In 1971 British tourists took 4 million holidays abroad, but by the end of the decade this had leapt to 13 million. In 1970 the Conservatives won power, but 4 years later they were out again after a series of strikes, power-cuts, the 3-day week, a financial crash and an oil crisis. Unemployment had climbed to 1 million (5% of the workforce). After years of fruitless negotiation, the UK had finally joined the European Economic Community. By the end of the decade, the Conservatives were in power once more as Britain was forced to ask for a bailout from the International Monetary Fund and Labour was humiliated by trade union militants in the "Winter of Discontent". In a seminal moment for UK politics, Margaret Thatcher became the first female prime minister.

Surveillance

By the end of the 1960s, TB in cattle had almost disappeared, driven by the policy of identifying and removing reactors. By the mid 1970s, all the cattle herds in the UK had been cleared of bovine TB (although not all at the same time). TB was first detected in badgers in 1971. The 1967 FMD outbreak was a catalyst for improved contingency planning for outbreaks, also illustrating the need for early detection of disease. In Scotland, surveillance capacity increased during the 1960s with the addition of three new Veterinary Investigation Centres (VI Centres) in Dumfries, St Boswells and Thurso. VI Officers (VIOs), funded entirely by the Department of Agriculture, Fisheries and Food for Scotland (DAFFS) worked closely with local vets and farmers and government in national disease eradication programmes, and with researchers and industry in addressing animal production problems such as parasite infections and trace element deficiencies.

1980s and 1990s: "Greed is Good"

Britain in the 1980s was characterised by class and racial tension, an economic recession, a boom, and another recession, with high unemployment (>3 million) throughout. After the end of the Falklands War in 1982, Margaret Thatcher's re-elected Conservative government embarked on a radical programme to privatise government-owned industries and utilities, disengage from industrial intervention and to cut income tax, aiming to reduce government expenditure and instill market disciplines. The miners' strike of 1984-85 left a legacy of bitterness and discontent in many areas; other areas boomed, with the "Big Bang" deregulation of financial services generating an era of excess. Subsequent recession, public dissent over the "Poll Tax" and squabbles over European integration led to Thatcher's removal from government. John Major won a surprise victory in 1992, completing the Thatcherite legacy by successfully reducing inflation and public spending and privatising the mines and railways, before succumbing to Euro-infighting. In response to four lost elections, Tony Blair introduced New Labour, which promised centrist government, fiscal rectitude, social liberalism and constitutional reform. By 1999, Scotland had a Parliament again, and although Scotland was signatory to a single Animal Health and Welfare Strategy for Great Britain, animal health matters were largely devolved. The World Wide Web was invented in 1989 and substantial increases in computing capability and accessibility captured the public imagination with new technological and scientific developments such as the Google search engine and the Human Genome Project. Computing power enabled epidemiologists to explore multifactorial associations between risk factors and disease and to simulate mathematical models of farming systems. UK agricultural workers had increased in number, and numbers of poultry, cattle and sheep reached all-time peaks (the latter as a result of the substantial Common Agricultural Policy payments). However, pig numbers were starting to decline because of decreasing farm profitability. At the start of the 1980s there were large numbers of abattoirs (~1000 in the UK), but this declined over the decade. BSE ("Mad Cow Disease") was first identified in 1986, triggering a human public health scare and a lengthy dispute between Britain and France regarding trade restrictions of British beef. The Agriculture minister, John Selwyn Gummer, attempted to calm public fears by eating a hamburger with his daughter, sparking a backlash of public scepticism and mistrust in experts. Andrew Wakefield's fraudulent study on the impact of the MMR vaccine on autism and the emergence of a public "anti-vaccine" movement illustrated the importance of good science communication and engagement with the public.

Surveillance

Cases of TB in England and Wales began to rise again. In the early 1980s, the main aims of the VI Centres were to support the State Veterinary Services in disease eradication and control schemes and provide advice to the agricultural community about farm animal diseases (Rayner Review 1984). However, the scope of the centres was subsequently expanded to include an emphasis on identification of new and emerging diseases (Dawson Report 1990). In 1995 the VI Centres in England and Wales amalgamated with the CVL to form the Veterinary Laboratories Agency (VLA). In Scotland, the surveillance centre in Oban was closed and the remaining VI centres were brought together under a single director. The 3 colleges of agriculture were merged to form the Scottish Agricultural College (SAC) and the veterinary advisory programme (incorporating the 8 VICs) was established to handle diagnostic materials. An internal review of surveillance in Scotland highlighted the challenges of data wastage and the importance of considering new technologies to improve rapid data sharing (Scudamore Review 1993). The World Trade Organisation treaty in 1995 defined animal health standards for trade, adding to the importance of surveillance systems in proving disease status.

2000 to the present day: "A Changing World"

The new millennium has been characterised by political and social unrest and an increase in terrorism and war following the 9/11 attacks and the London bombings. Bush and Blair led the USA and UK into a badly planned war in Iraq, leading to massive public discontent. The Arab Spring marked the beginning of a series of anti-government uprisings and protests that spread across the Middle East, sparking an intractable civil war in Syria and the rise of Daesh. Terrorism spread westwards into Turkey, France and Belgium increasing public fear and uncertainty. This resulted in an increase in anti-immigrant and anti-Muslim sentiments. The EU (incorporating 10 new states) became a "safe haven" for millions of refugees fleeing these conflicts, but fears of uncontrolled increased immigration of economic migrants and refugees were a significant factor in Britain's decision to leave the European Union in 2016.

Social media (Twitter, Facebook) emerged as a communication tool empowering "millennials" through the use of smart mobile devices, changing the nature of "personal" and "private", and introducing new types of entrepreneurial activity. Google Earth and Wikipedia kick-started the democratisation of data and apps to crowd-source data flourished after a series of natural environmental and public health catastrophes (e.g. the earthquakes in Haiti and Nepal, Ebola outbreaks) illustrated their value in emergency surveillance and disaster management. Environmental priorities and climate change goals continued to move up the political agenda after the Kyoto Protocol was agreed. In the UK, the FMD outbreak in 2001 resulted in the destruction of millions of animals and significant damage to the rural economy and society as a result of losses to small businesses and in tourism. As a result, the numbers of agricultural workers declined (to ~200,000), mirroring the decreasing trend in populations of cattle, sheep and pigs. As more unvaccinated children entered school (because of anti-vax hysteria), there were localised outbreaks of measles. A number of other major public health outbreaks (e.g. SARS, "swine flu", Ebola, Zika and AMR) have highlighted global inequalities in public health law and infrastructures and the need for better global collaboration.

Surveillance

Following the food scares of the 80s and 90s, responsibility for food safety was moved to the new Food Standards Agency in 2000. "Syndromic surveillance" emerged as a concept for detection of disease clusters, particularly in response to fears of bioterrorism. The 2001 FMD outbreak (and 2003 UK Veterinary Surveillance Strategy) highlighted the importance of cross-border partnerships and surveillance activities, which produce high quality, high value data and effectively incorporate stakeholder intelligence to minimise the impact of animal disease outbreaks. Data sharing was also prioritised, and RADAR, a data-sharing warehouse, was created. In the aftermath of FMD, veterinary epidemiology capacity was increased through research funding (e.g. EPIC, a Centre of Expertise on Animal Outbreaks). The cattle tracing system and a Scottish Electronic Identification (EID) system for pigs and sheep improved data capture on animal movements and enabled epidemiologists to explore the properties of movement networks using mathematical models. In 2011, the Veterinary Laboratories Agency amalgamated with the Animal Health Agency to form the Animal Health and Veterinary Laboratories Agency (AHVLA), with 14 regional laboratories in England and Wales and two surveillance centres (co-located to Liverpool University and the Royal Veterinary College London). An AHVLA laboratory in Scotland was co-located with the Moredun Institute. The Scottish VI Centres were renamed "Disease Surveillance Centres" to highlight their primary role for government. The AHVLA's collaboration with SAC through the adoption of common protocols and definition of disease conditions improved surveillance and generated the first GB-wide quarterly livestock surveillance reports. In 2011, the first independent review of surveillance in Scotland, the Kinnaird Report, investigated the resiliency of active and passive surveillance activities and whether or not these met the needs of Scottish Government stakeholders. It was concluded that there remained important gaps in data collection and sharing, particularly in remote, rural areas.


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