Achieving the Glasgow Green Deal with an aerial-based MRV system

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OVERVIEW

Contents of today's information on proposed monitoring, reporting and verification tool

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An overview of the proposed tool, its scope of use and top-level considerations

II

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IMPLEMENTATION

The next steps which are required to start using the tool.

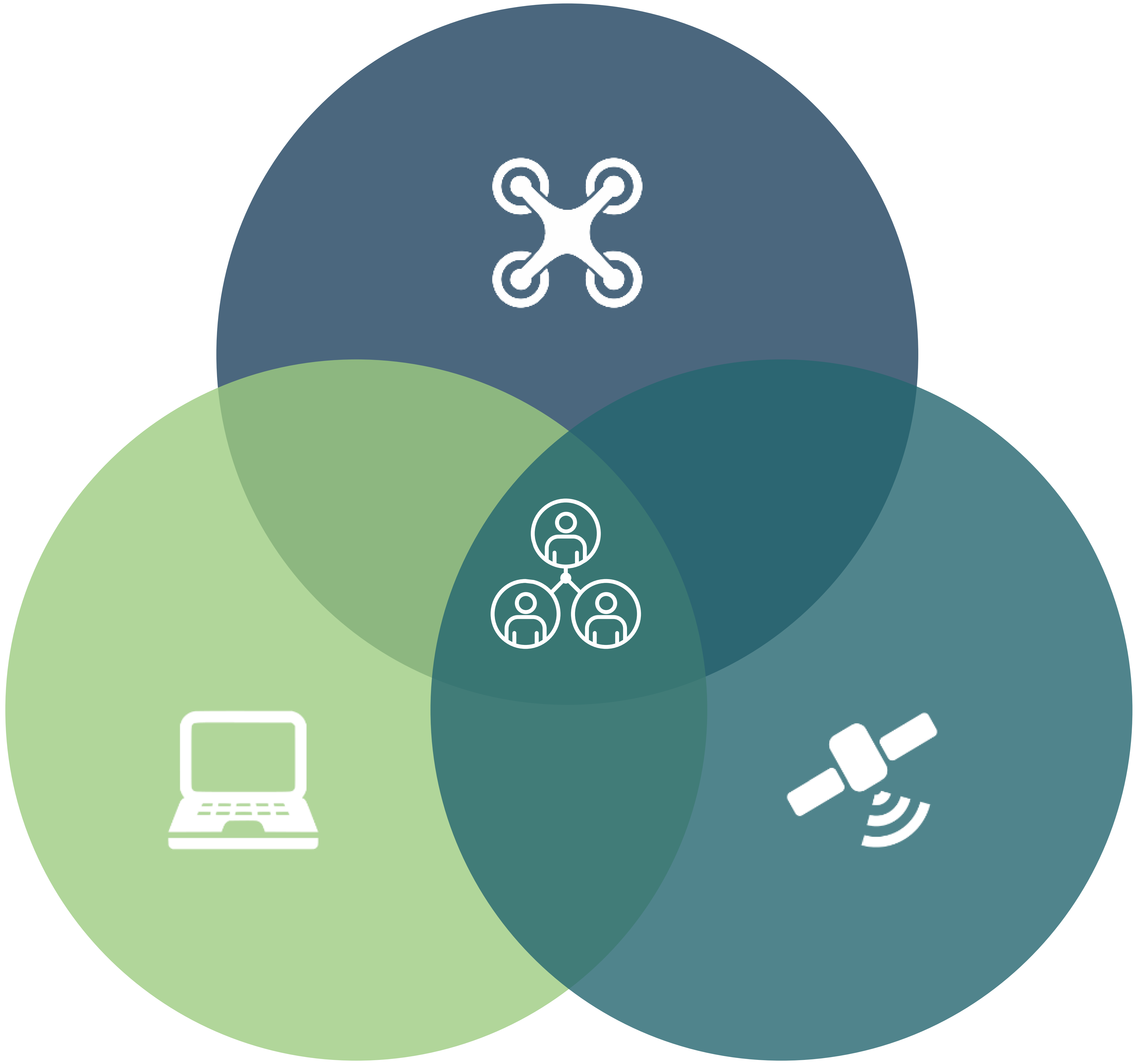
IV

FINANCIALS

Cost of the proposed solution and expected social benefit.

DATA SOURCES

Drones, satellites and self-reporting



SATELLITES + NATIONAL DATA

Baseline calculations, CO_2e emissions, aggregate use of land, emissions by sector type.

DRONES

CO_2e emissions, project specific variables (such as land use, imagery and heat)

SELF-REPORTING

Non-grid consumption, extracts from Companies House/OSCR, ancillary data.

GRID INTERACTIONS

Consumption, grid intakes (if applicable).

SCOPE | Attract investment to all project types

Achieving the Glasgow Green Deal with the recommended set of data sources

ENERGY EFFICIENCY

Tracking the use of fuel through grid offtakes and Companies House/OSCR revenue and profit data

MOBILITY INFRASTRUCTURE

Tracking transport emissions with better granularity, incl. non-motorway traffic

RESTORING NATURE

Using drone imagery and data to maintain animal and plant ecosystems

RENEWABLES

Measuring grid intakes by site, as well as how these intakes relate with demand

REDUCING EMISSIONS

Monitoring CO_2 emissions with high resolution data

CIRCULAR ECONOMY

Use approximated data on waste + self-reporting, to encourage recycling

QUALITY | Provide detail for long-term savings

Drones are seen to have increased effectiveness than static and satellite alternatives

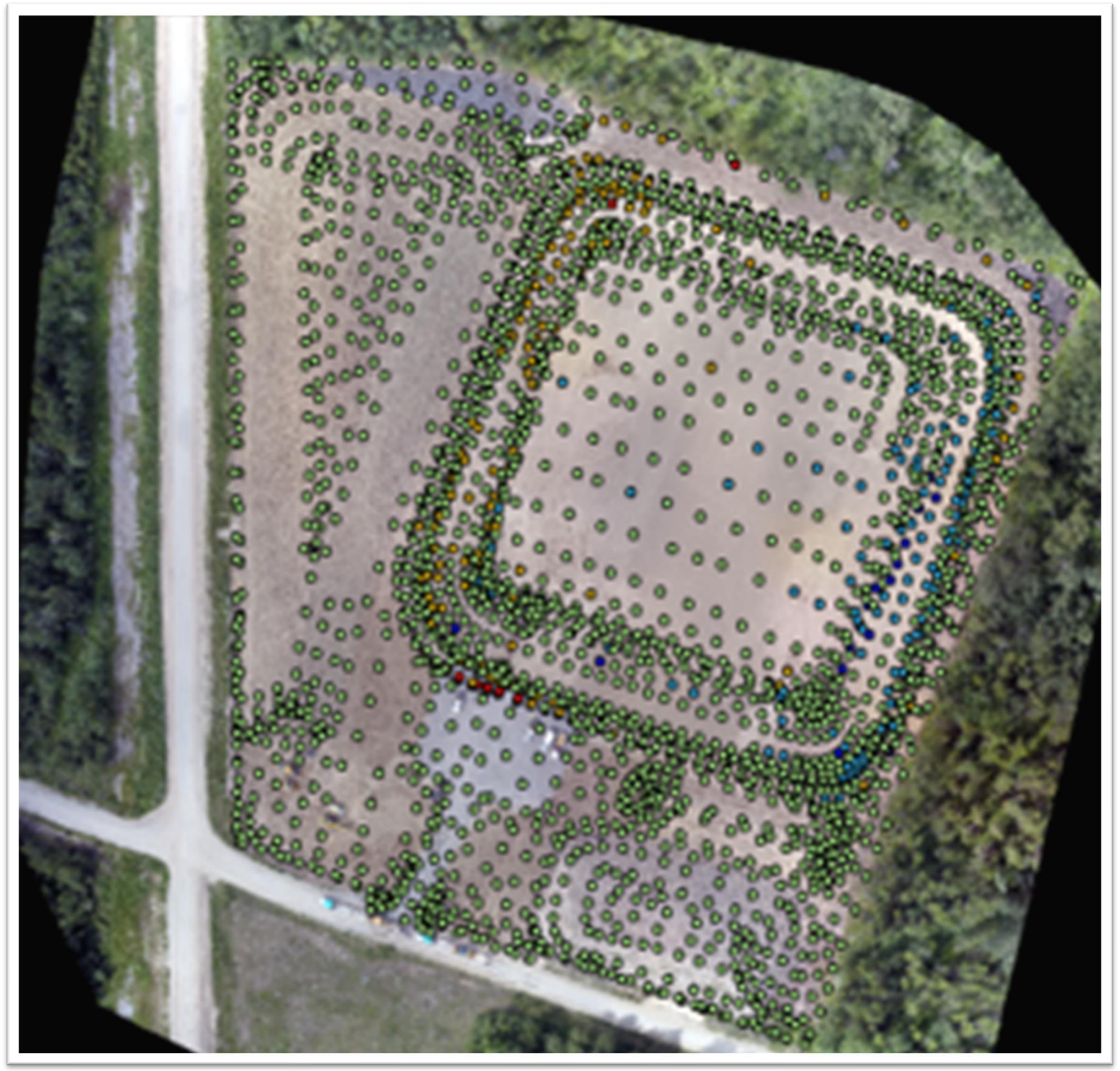
The "Epic Duck Challenge" proved drones (both unmanned and remotely piloted) were 43%-96% more effective than human monitoring *(Hodgson et al., 2018)*.

WHY

GPS linked perfectly with satellite data to focus on emissions-heavy areas.

Complement satellite data (picture resolution, heat sensing (animals/indoor heat), & *emissions granularity*). Many other examples!

Moveable objects can gain more from new software relative to static alternatives.



10,000x more data in 1/10th of the time
(Billingsley, 2022)

Source: Full references available on request.

ADAPTABILITY | Focus where needed

Drones are seen to have increased effectiveness than static alternatives

Housing Retrofit project

- Aiming to improve efficiency of 428,000 houses
- Need to track progress (high prices may discourage consumption)

Measuring home temperatures

- Installing measuring devices in every home is expensive
- Use drones + grid offtakes.

Next project

- After the project is completed, the drones can move elsewhere.
- Accurate results + cheaper over the spread of projects.

Source: Glasgow Green Deal, 2021.

LOCATION ACCESS | Access any project

Drones can access spaces that traditional measurement devices cannot go to

Royston

Industrial sites

Port Dundas

Uneven terrain

Woodlands

High speed roads

Accessing off-road sites

Instantly report data for project use

Height advantage (birds eye view)

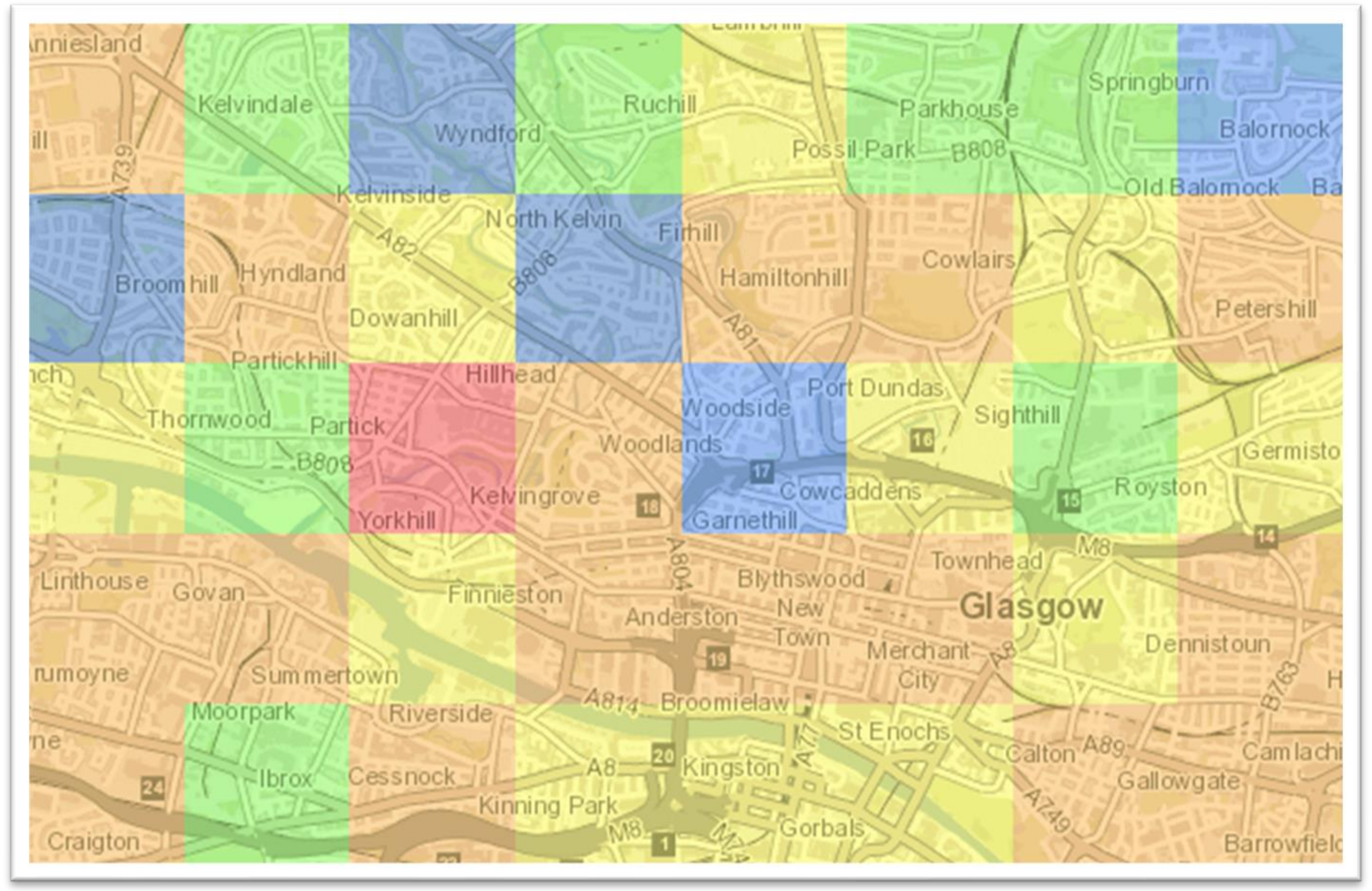
Access areas dangerous to humans

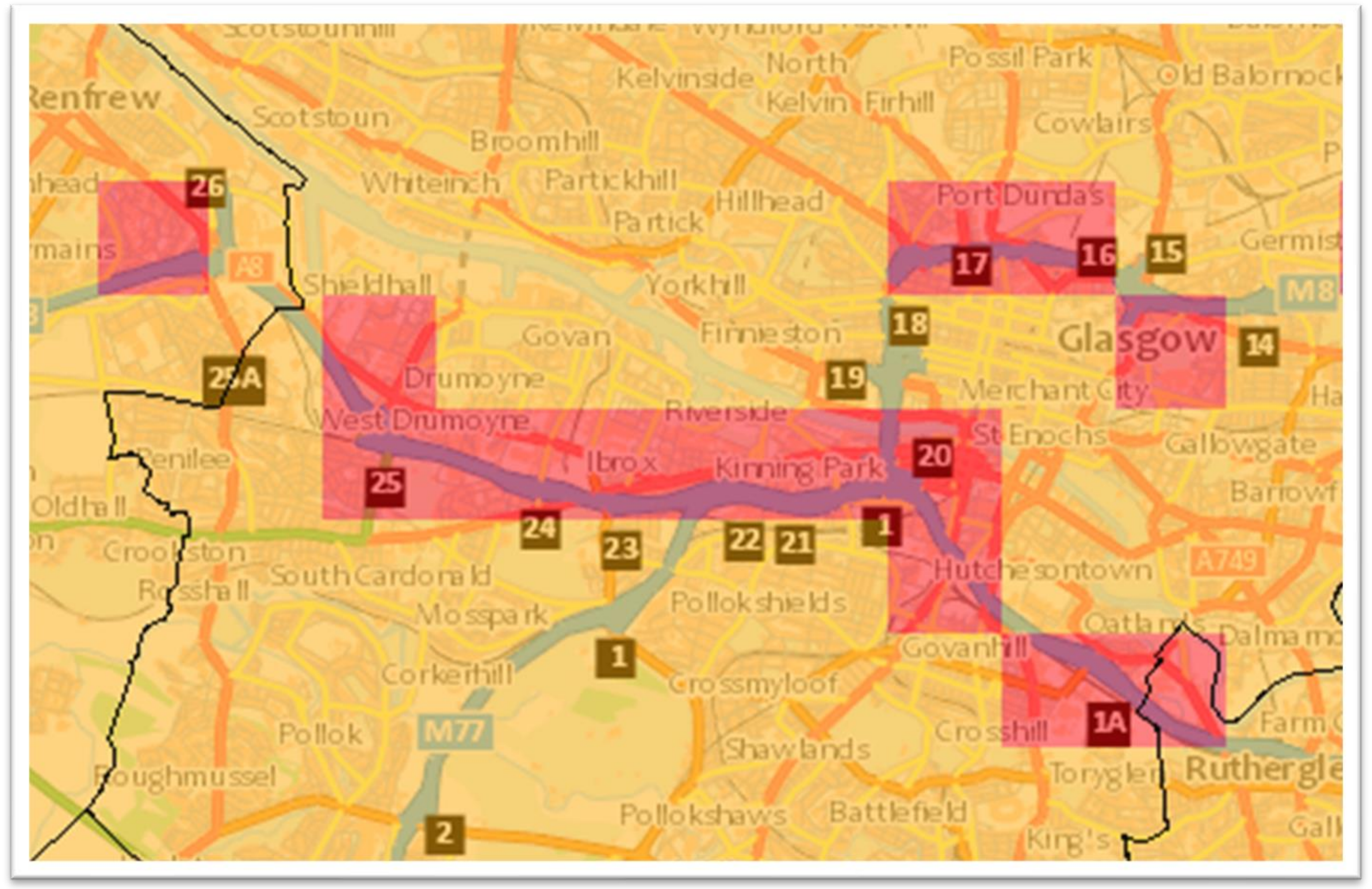
Don't have to wait in traffic!

Source: Google Maps, 2022.

GRANULARITY | No more ambiguity

Track the progress of projects, no matter the size





Source: National Atmospheric Emissions Inventory, 2022.

M8, M74 and M77 traffic emissions

- Even at a 1km x 1km resolution, the cause is obvious.
- Car density, etc. tracked by Traffic Scotland.
- Similar statistics at a local level (i.e. Byres Road), not available.

Manufacturing Industry Combustion

- Extremely difficult to tell where emissions have stemmed from.
- Universities research buildings? NHSGGC Medical Devices Unit?
- Alternatively, it could be miscategorised in current data.

ANCILLARY DATA | Prosperity and equality

Achieving sustainability for prosperity and equality

Admittedly, drones cannot *directly* track money across projects.

Encourage academic study to find further relationships between measurable metrics and inequality (Gini Coefficient) or prosperity (GDP). We already know sustainability is linked with improved equality *(UNDP, 2013)*.

Re-visiting the Retrofit project, it’s likely that more efficient houses will improve welfare by reducing fuel poverty.

Ancillary information will be the main self-reporting aspect of our MRV. Companies will report each worker's income, the project's financial savings/profitability, and be given a survey to encourage each worker to provide their demographics (for a £10 voucher).

Source: Full references available on request.

BASELINE CALCULATION | Enact the MRV now

Projects baselines will be calculated from a done flyover plus historic data

1. Three random flyovers every month for three months
2. Emissions for rest of year calculated based on historic data
3. Expert makes considerations beyond flyovers and historic data
4. Bi-annual recalculations for first two years

For example,

1. A new public sector project aims to reduce industrial combustion CO_2 equivalent near Yorkhill. Drones take CO_2 readings near the industrial projects to increase data granularity.

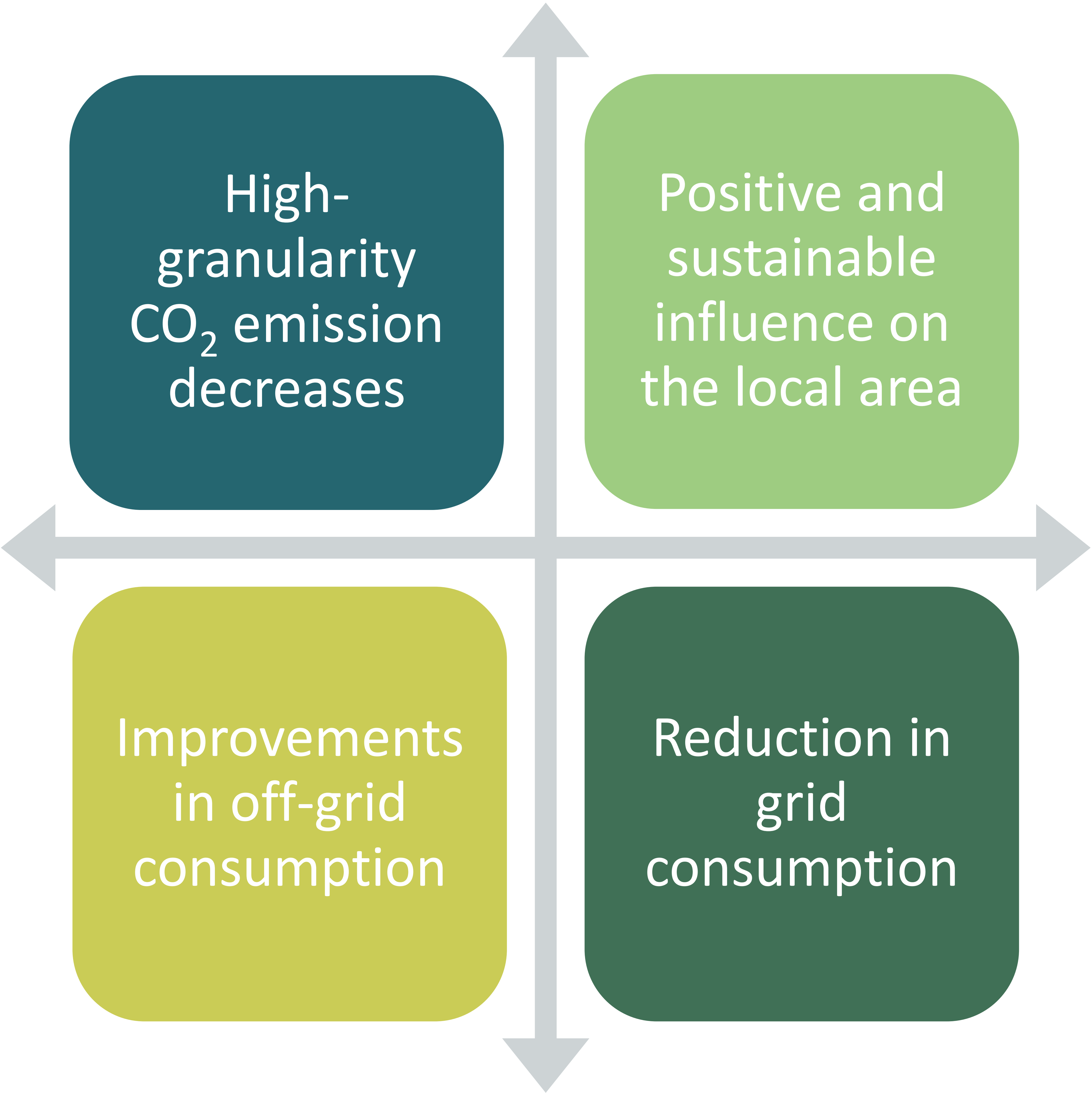
2. Due to increased production in Summer, there is a pattern of higher emissions over this period. A model accounts for reductions in emissions at this time as particularly impressive.

3. At one location, transport emissions are seen to influence readings so this is accounted for.

4. A reduction in road traffic leads to less residual emissions, so the creditable reductions are reduced.

PROJECT SCORING | Scoring for award process

Environmental measurements can be adapted by project, to determine the best measures for future sustainability



Each project will be scored (where positive is good), and the data will be reported to relevant rewarding/taxing agencies.

β_0 will usually be negative and represent expected progress (as set in the baseline).

Coefficients will be set based on the urgency of each variable.

μ is a correction based on positive spillovers into the project from elsewhere.

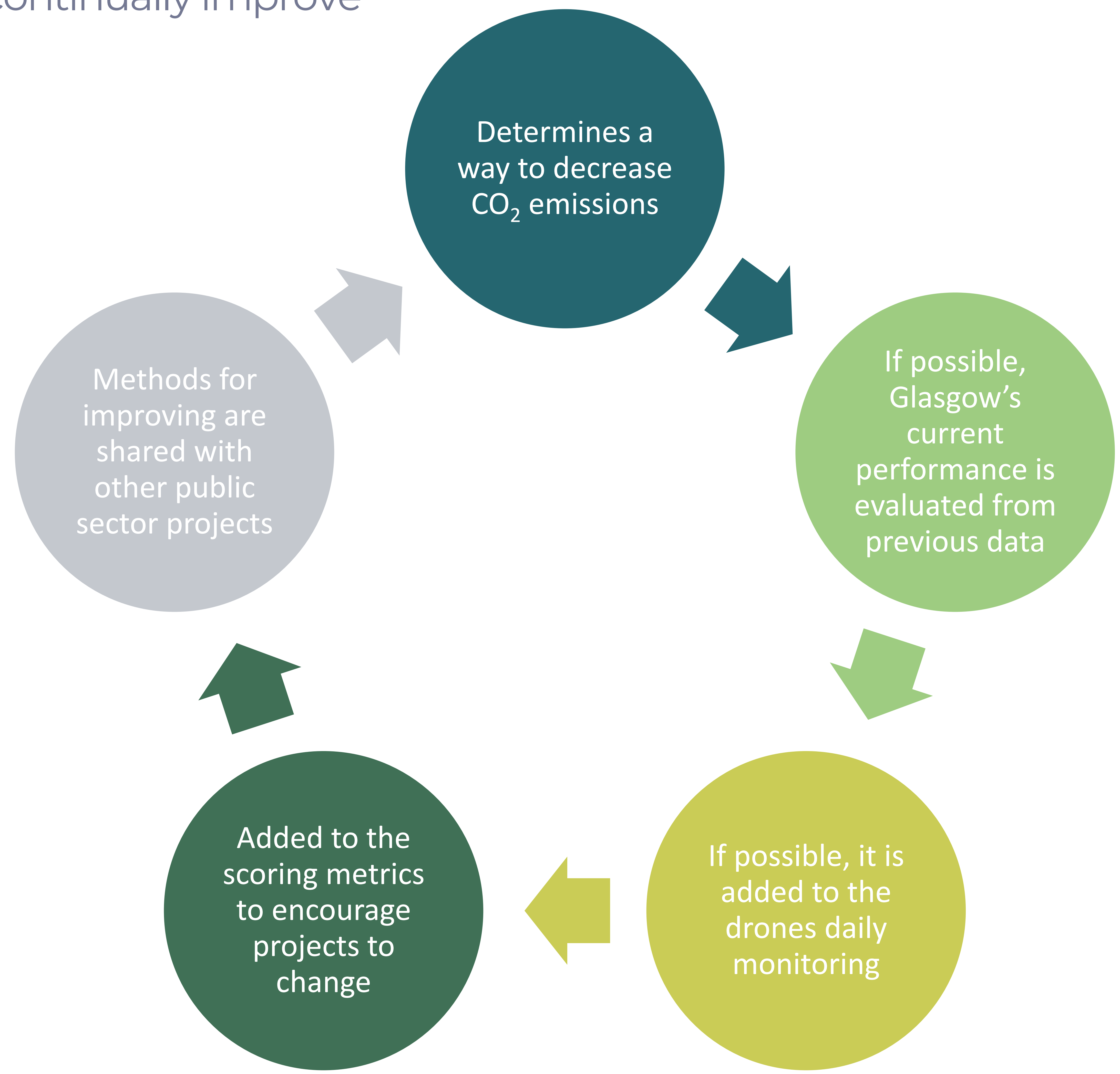
$$Score = \beta_0 + \beta_1 * -\Delta CO_2 e + \beta_2 * -\Delta consumption + \beta_3 * equality + \beta_4 * \$benefit + \cdots - \mu$$

EXPECT IMPROVEMENT | Evolve with time

Unlike static projects, it is easier to make changes and continually improve

- Whenever measurable, new ideas will be added to the system when possible.
- Drones can monitor as soon as static tools can (provided the monitoring device is a reasonable size).
- Glasgow's MRV system will compound to have many (sometimes sector-specific) monitoring criteria.

Ancillary data – correlations with prosperity/equality studied against measurable variables.



II

MARKET ANALYSIS

Investigation of existing MRV tools, and how aerial-based compares.

GLASGOW – STATIC DIGITAL

Glasgow's existing solution is expensive and hard to update

- **Costs:** Cost per location is high as technology cannot be divided over multiple areas of Glasgow.
    - Similar technology quoted upwards of £8000/location.
- **Adaptability:** If a project ends, technology cannot be easily moved.
    - Unsuitable for temporary projects.
    - New technology cannot be easily installed.
- **Reliability:** Devices are more susceptible to damage than a drone that flies far away from people.
- **Quality:** Data only represents one exact location. Wind movement could affect readings.

Source: Full references available on request.

GERMANY – STATIC MANUAL

Third National Forest Inventory project in Germany (2011/2012)

- **Costs:** Cost is high due to the high amount of manual labour.
  - 60 teams are required for a long time period.
  - 150 characteristics of each sample point.
  - 420,000 trees were checked for a reasonable sample.

- **Adaptability:** tools can be re-used, but re-hiring is likely.
  - Staff likely to fatigue after thousands of measurements. Training is needed for new staff.
  - Cannot measure a new area with short notice.

- **Reliability:** The large sample size and pair measuring process is highly reliable.
  - Can access uneven terrain.

- **Quality:** Data is high quality and accurate.
  - Getting enough data for quality is very time-consuming (2-year project)

Source: Full references available on request.

MEXICO – MANNED AIRCRAFT

Monitoring Intense oceanic fronts in the Northern Gulf of Mexico.

- **Quality:** high resolution of data due to
  - Data is captured at a 5m x 5m resolution.
- **Reliability:** Large areas be monitored in a short period of time.
  - Aeroplanes are faster than other forms of transport.
- **Costs:** Costs are exceptionally high. Highly negative impact on the environment.
  - Pilot, airport, and deterioration costs are expensive.
  - 10 tonnes of jet fuel are consumed every hour.
- **Adaptability:** Cannot use other tracking tools due to high speed.

Source: Full references available on request.

WORLDWIDE – VEHICLE TRACKING

AIS individual vessel tracker to monitor CO2 emission developed by Ricardo Energy & Environment

- **Costs:** Significantly lower than most other options.
  - ➢ Ranges from £160 to £320
- **Quality:** estimation of fuel consumption of auxiliary engines relies on assumptions.
  - ➢ Quality is compromised here as auxiliary engines could be particularly emissions-heavy.
- **Reliability:** the fuel consumption of domestic shipping is consistent with that in the national navigation report.
  - ➢ Measurement tools are unreliable when at berth for over 24 hours.
- **Adaptability:** adapted to track all kinds of and large-scale quantities of ships and vessels.
  - ➢ Movement between ships is more effort than a replacement.

Source: Full references available on request.

ANALYSIS OF DRONE MONITORING

Analysis into where drones are already successful in use

Project	Information + any challenges	Solution
Rio Tinto	In 2020, drones ensured that mining equipment was not disruptive to local bat habitation in Australia.	No remedy is required.
Quelling Oakland Fire	In 2016, drones completed Search & Rescue in a fire with thermal cameras. Battery life was problematic.	High-quality drones plus 60 minute flight slots.
Manam Gas Monitoring	Drones access hazardous environment to collect special data. Volcanic environmental harmed flight capability.	Issue not applicable in Glasgow.
Coastal Carbon Opportunities	Drones used to replace field measurement to monitor mangroves biomass in Avicennia marina mangroves in SA. They provided high accuracy of trees height with high resolution data. Prediction error on diameter measurement is high.	Digital monitoring devices proposed for Glasgow.

Source: Full references available on request.

LITERATURE REVIEW

Reviewing analysis by academics

Paper	Learnings
Hassananlian and Abdelkefi (2017)	➢ Purchase a **spare drone** in case of technical errors. ➢ Use **autopilot tools** where possible to avoid human error. ➢ Renewables are not great – **Hydrogen** is a better alternative.
Floreano and Wood (2015)	➢ **Fixed-wing** UAVs are more reliable and long-range. ➢ Fly **below 120m** to avoid interference with manned aircraft. ➢ **External validity** beyond Glasgow could be limited due to differing legislation on drones.
Kardasz et al. (2016)	➢ Battery-powered or electric drones have limited use **(>15min flight**) ➢ Larger military drones often **use internal combustion engines**. ➢ **Multi-engine** drones should be used to mitigate the risk of crashes.

Source: Full references available on request.

MARKET FACTORS

Qualitative analysis of alternative monitoring tools

Reliability

- Most projects are reliable at completing specific task.

Quality

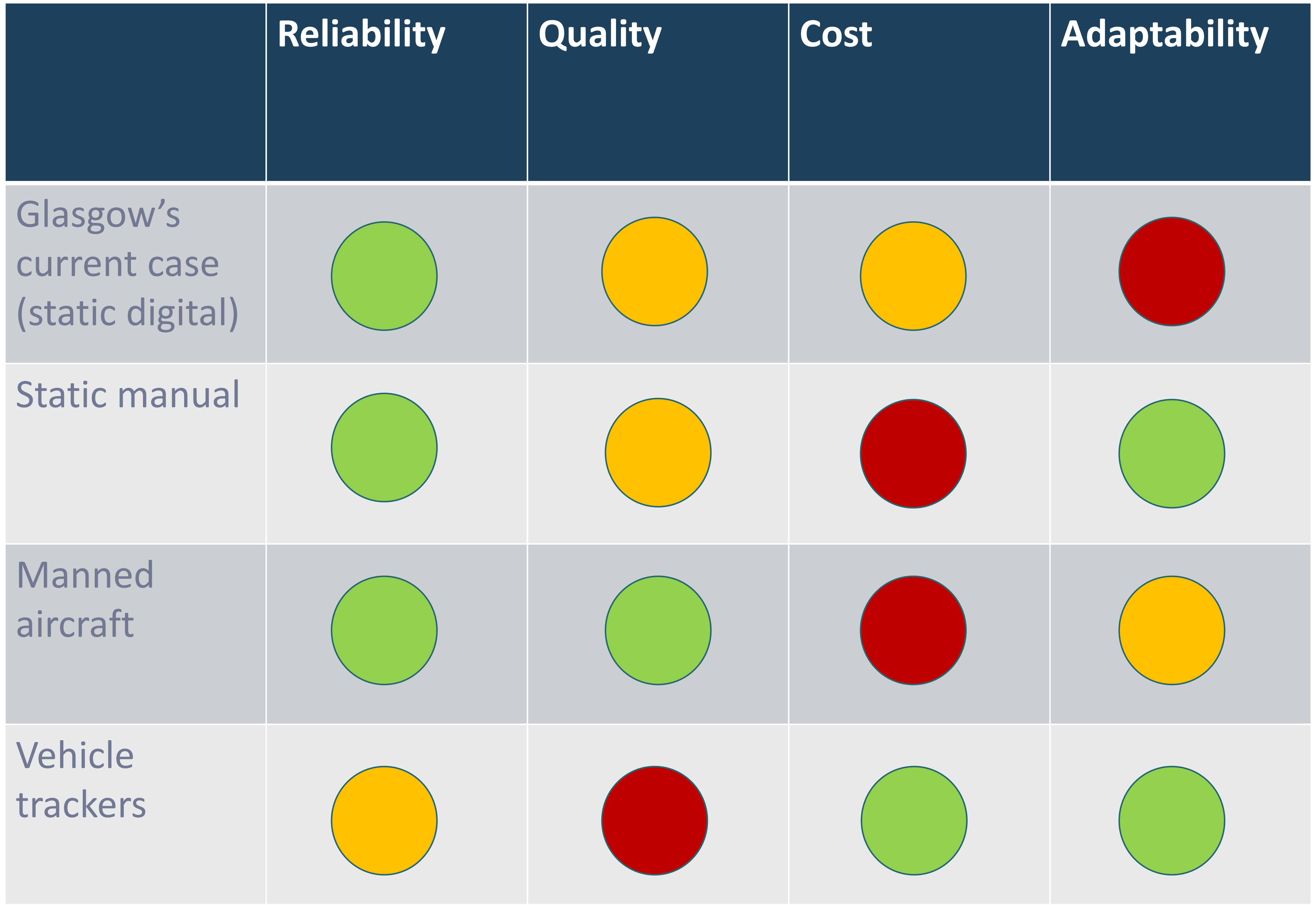
- Quality can be impeded by lack of flexibility.

Cost

- Cost is particularly high across most alternative solutions.

Adaptability

- Most alternatives are unable to adapt quickly.



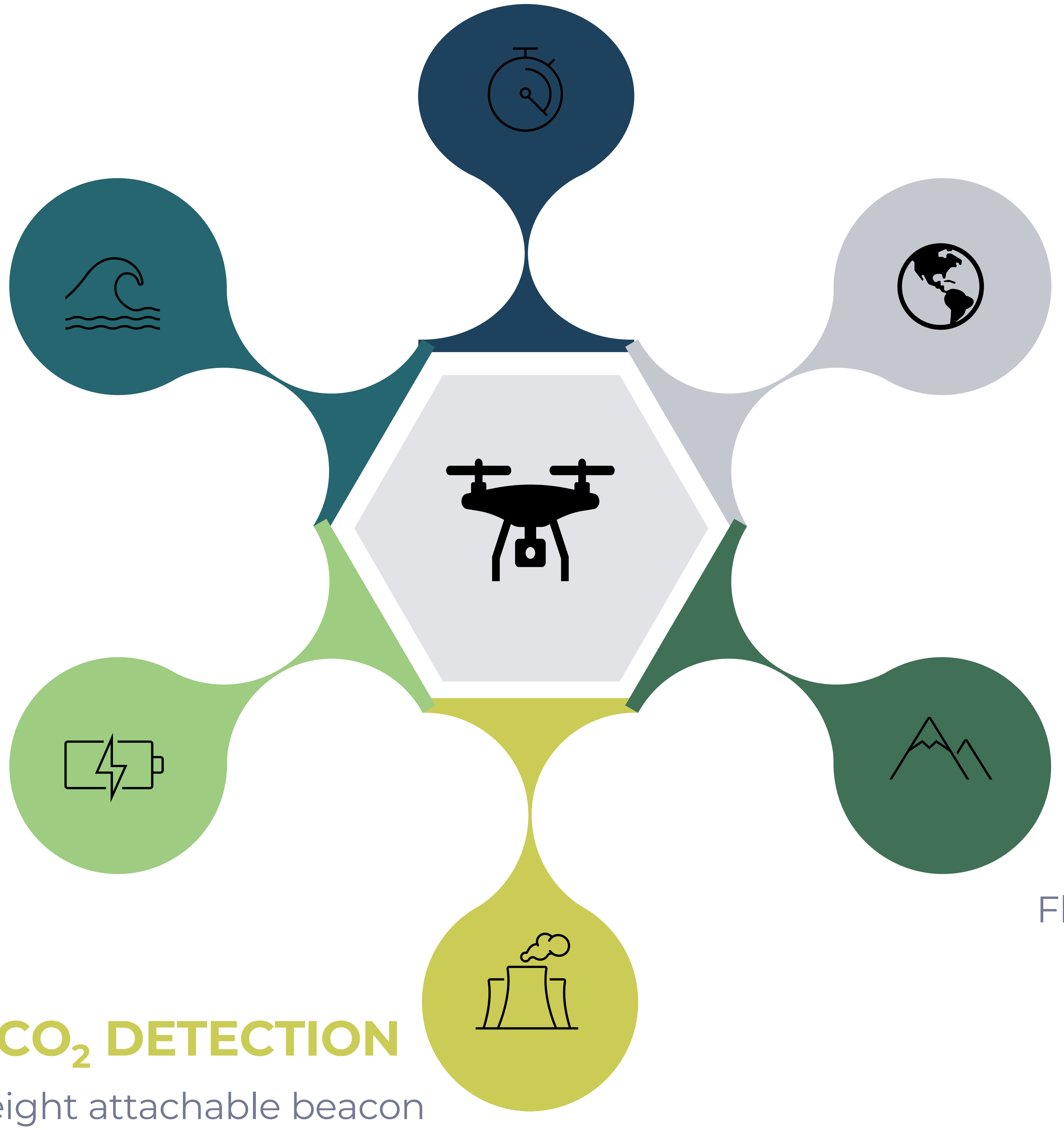
III

IMPLEMENTATION

The next steps which are required to start using the tool.

DRONE DESIGN

Structural aspects of the drone for maximum efficiency



FLIGHT TIME

60 minutes to 2 hours

WATERPROOF TECHNOLOGY

Drones will be waterproof, due to Glasgow weather

COVERAGE

Minimum 20-kilometre range

SUSTAINABILITY

Hydrogen fuelled

ALTITUDE

Fly at approximately 100 metres

CO_2 DETECTION

Lightweight attachable beacon sensor

DRONE REPORTING

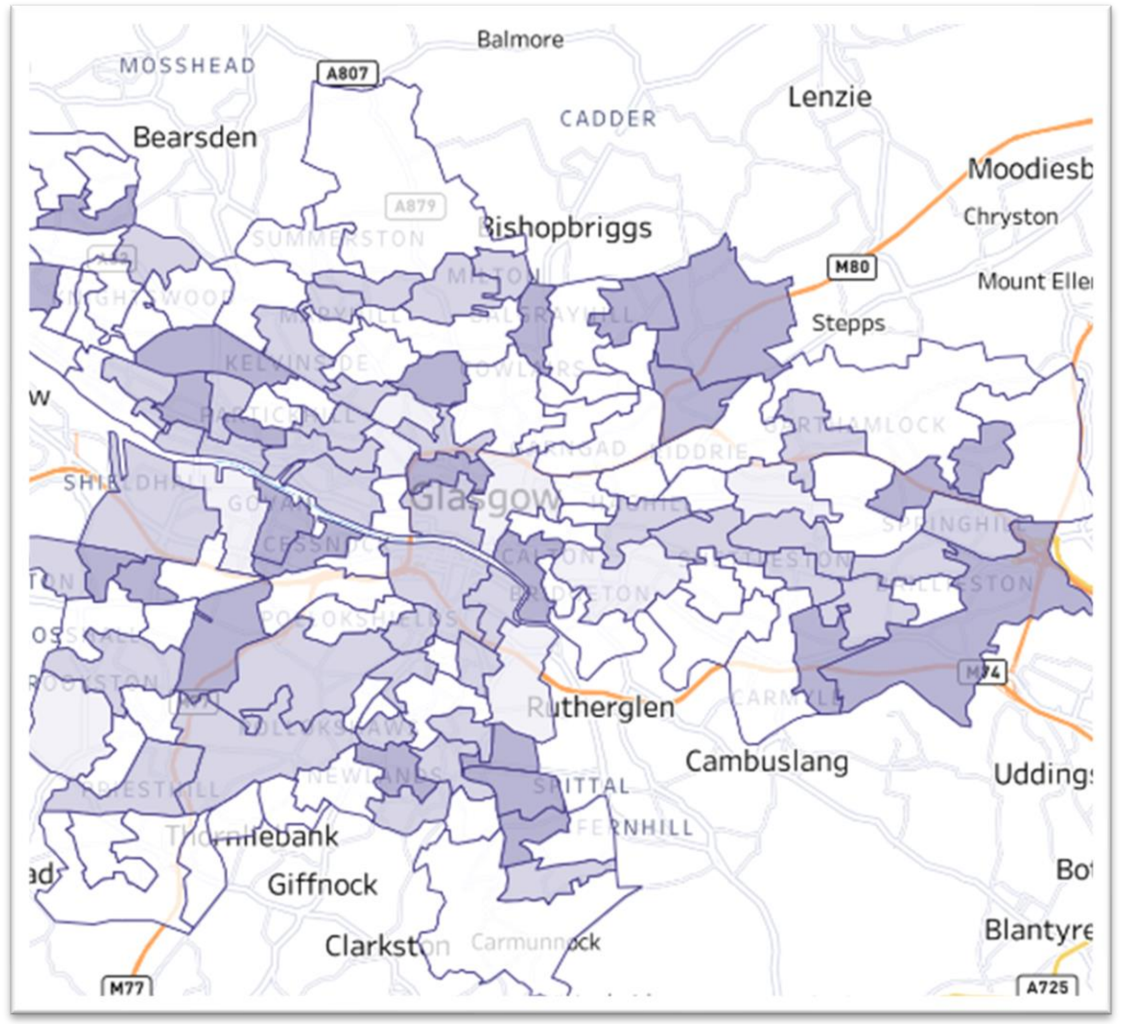
Drones automate monitoring and reporting, and use the explained verification framework

Automatic collection of data from drones and grid → Self-reported data sent manually to administrator (monthly) → Sent to online Tableau database with charts (Salesforce)

Check for anomalies over a threshold and expected improvement	
Expert check	Change expectations if needed

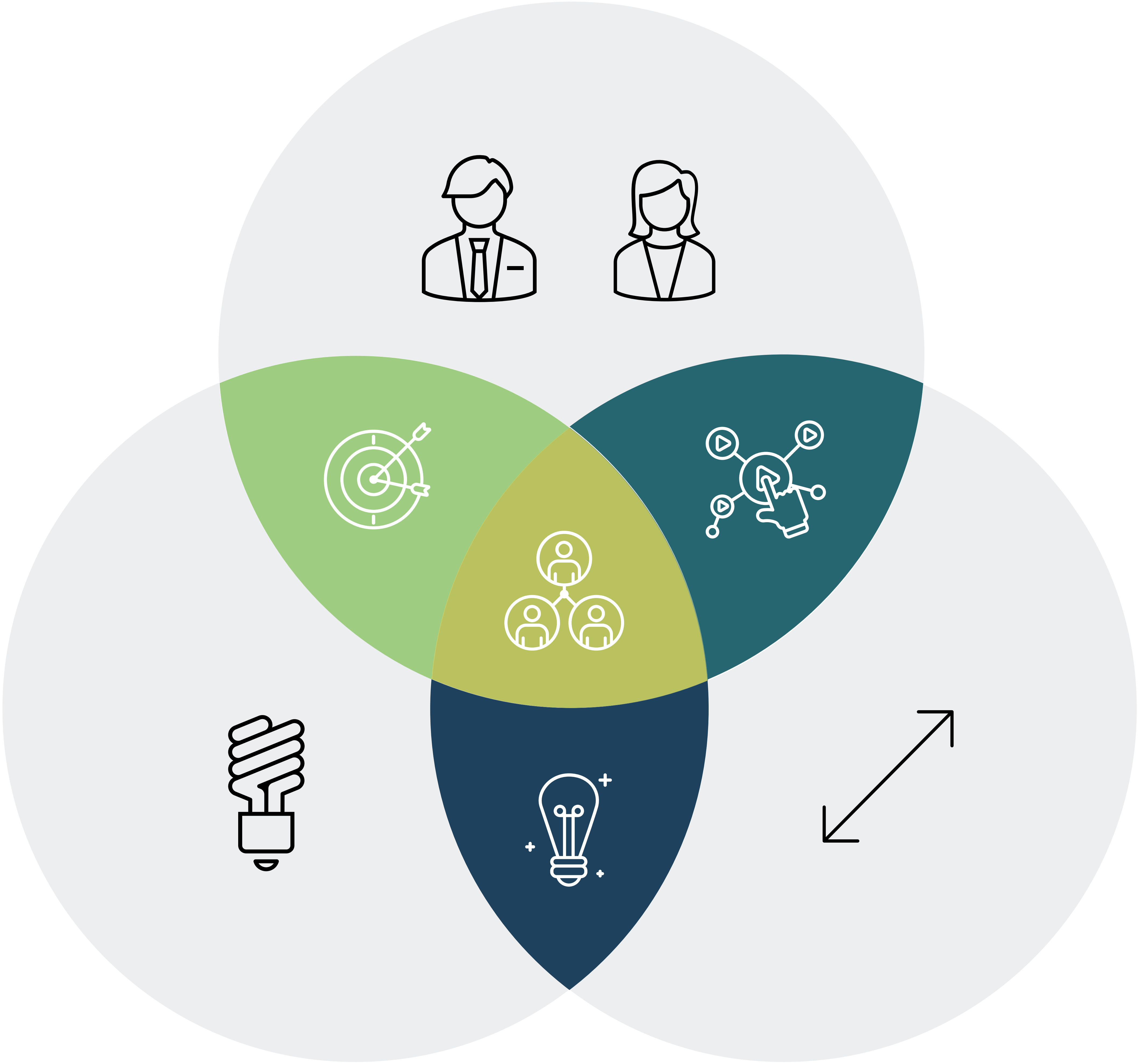
Projects are rewarded based on incentive structures	
Short term: £200/t/CO2e	**Long-term:** Increased leverage/ savings

Additional metrics are added based on regular expert reviews	
Is this sustainable?	Which projects move to long-term?



VERIFICATION

Ensuring validity of the results reported by drones



EXPERT REVIEW

Manual inspections in the reporting process to check reductions are legitimate

EXTERNAL FACTORS

Comparing drone data with self-reported statistics

ADAPTABILITY

Adding new factors to our scoring calculation if they are relevant

SYSTEM COSTS

Structural aspects of the drone for maximum efficiency

Drones

- UAV - £4,000 (short-range) to £15,000 (long-range), depending on the number of monitored projects
- CO_2 emissions device – circa £600-£1000/per drone
- **Total estimated cost:** £40,000-£50,000 (CAPEX) plus £20,000 per additional drone.

Staff

- Staff costs: Drone operator (£30,000) + subject expert/auditor (£50,000) + admin assistant (£25,000).
- Extra costs: National insurance/pension (£25,000), office (£8,000).
- **Total cost:** £146,500 (annual OPEX)

Maintenence

- Heating and electric costs (£3,500)
- General drone maintenance and repairs (£4,000)
- **Total cost:** £13,500 incl. a miscellaneous budget (£6,000)

IV

FINANCIALS

Expected social benefit

TRANSFORMATIONAL

Drone-based MRV systems for at-scale delivery

Type of Adaptation	Type of Finance: Conventional finance	Type of Finance: Transformative finance
Incremental adaptation	Public sector funds using grants, i.e. business as usual	New instruments or financing models to scale-up adaptation
Transformational adaptation	Public sector funds for new innovative adaptation or delivering at scale	New instruments/ financing models for innovative and systemic adaptation

Transformational adaption based on delivery in the scoring mechanism

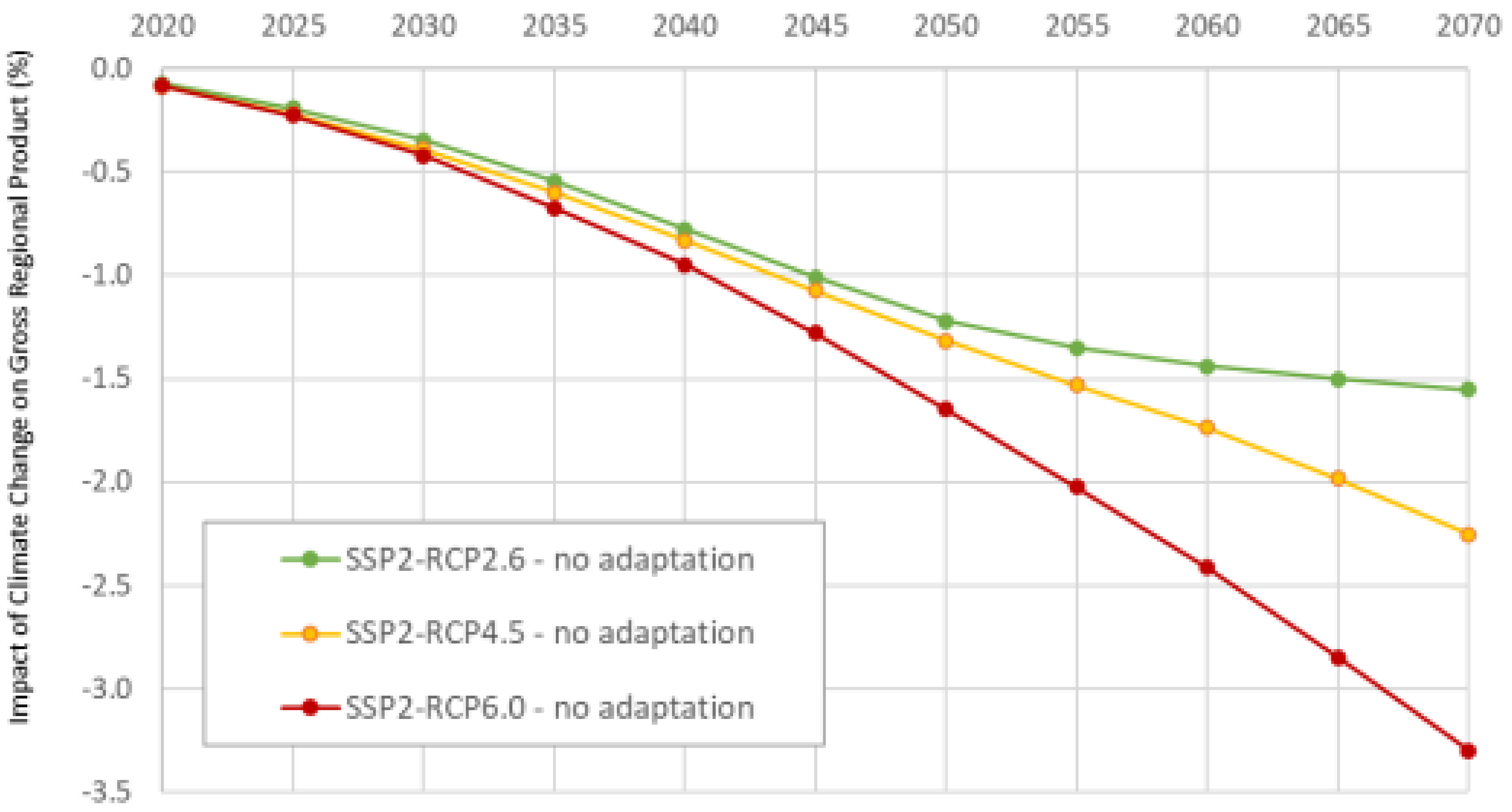
Financing models can integrate with the proposed MRV easily

Ongoing opportunity for improvement based on new technology

Source: Climate Ready Clyde, 2021.

MRV COSTS AND GAINS

Avoid disputes on whether climate actions are on target and devastating consequences



Total annual cost of MRV = £160k

£0.45 billion without move to long term financing

Even at RCP2.6 concentrations, GDP losses are moderate compared to global. Glasgow's emissions negatively effect other nations/cities (though could be closer to home).

Exacerbated at plausible and bad cases.

EU missed targets in 20-20-20.

Expected benefit: £1.03 billion*

*other workable MRV solutions would deliver some of this benefit.

Source: Climate Ready Clyde, 2021. Wood Mackenzie, 2022. European Court of Auditors, 2022.

SUMMARY

Environmental measurements can be adapted by project, to determine the best measures for future sustainability

INSTANTLY AVAILABLE DATA

COST << BENEFIT

LATEST CARBON MEASURING TOOLS

READY FOR EXISTING GGD PROJECTS

EASILY UPDATE WITH NEW TRACKERS

REACH RCP2.6

Questions