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Strategy Execution and Application for the Impact of COVID-19 on Society --Analyses on Sustainability and Resilience with the Application of Artificial Intelligence Countermeasures—

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--***ABSTRACT***--
COVID-19 broke out at the end of 2019 and it has been nearly five and a half years. However, the impact of its variants on people has become a hot topic in society. Although various vaccines have been invented and provided for use, people still feel uneasy. This article will start with the characteristics of COVID-19 and its impact on society, and will also discuss the measures taken by countries around the world. The author will further analyze the impact of COVID-19 on the general public from the perspective of sustainability and resilience, and propose appropriate responses with some examples around the world. At the same time, the characteristics of artificial intelligence and the countermeasures it can provide to COVID-19 will be discussed on both construction and climate change. Finally, the paper combines the characteristics of sustainability, resilience, and AI to apply them to address COVID-19 and climate change, and draws clear conclusions on strategies for engineering and national development.
Keywords: *COVID-19, Vaccine, Sustainability, Resilience, Artificial Intelligence(AI).*

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I. INTRODUCTION

1.1 Coronavirus disease 2019 (COVID-19)

COVID-19is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which has caused an ongoing epidemic and become one of the deadliest epidemics in human history.Common symptoms of the disease include fever, cough, fatigue, shortness of breath, loss of taste and smell (Daniel P Oran , and Eric J Topol, 2021)., muscle aches, etc. The time from infection to onset of symptoms is usually 1 to 14 days. At least one-third of infected individuals are asymptomatic (Lydia Bourouiba, 2020). The majority of patients with significant symptoms (81%) had mild to moderate symptoms (at most mild pneumonia), while 14% had severe symptoms (dyspnea, hypoxia, or more than 50% lung involvement on imaging), and 5% had critical symptoms (respiratory failure, shock, or multiple organ failure). Older adults or those with underlying medical conditions are at higher risk for severe symptoms. The virus is primarily spread through oral and nasal secretions, including droplets produced by coughing, sneezing, and talking. These droplets do not usually travel long distances through the air. However, people standing close together can become infected by inhaling these droplets. People can also become infected by touching contaminated surfaces and then touching their own faces. In enclosed spaces, it can also spread through aerosols that can remain suspended in the air for long periods of time. The virus is most contagious during the first three days after the onset of symptoms, although transmission is possible before symptoms appear and in people without symptoms. Studies have shown that approximately 40%-45% of patients are asymptomatic.Several tests have been developed to diagnose the disease, with the standard approach being detection of viral nucleic acid by reverse transcriptase polymerase chain reaction (rRT-PCR), transcript-mediated amplification (RMA), or reverse transcriptase loop-mediated isothermal amplification (RT-LAMP) from nasopharyngeal swabs. Chest CT imaging is also helpful in diagnosing individuals with a high suspicion of infection based on symptoms and risk factors.Preventive measures include frequent hand washing, maintaining social distance, quarantine, indoor ventilation, covering your mouth and nose when coughing, and avoiding touching your face with unwashed hands. Wearing a mask in public places can be very effective in reducing the risk of transmission.Several COVID-19 vaccines have been approved and distributed in different countries, and mass vaccination campaigns have been launched. Other preventive measures include physical distancing or social distancing, isolation, ventilation of indoor spaces, use of masks or face coverings in public places, covering coughs and sneezes, and washing hands and keeping unwashed hands away from the face. Although drugs are being developed to inhibit the virus, the main treatment approach is symptomatic; management includes treatment of symptoms through supportive care, isolation, and experimental measures.

1.2 Sustainability and Resilience

Sustainability has been a core conceptual framework for community development. Resilience emerged more gradually out of ecological studies emerged as a focus of public interest as a way of responding and adapting to the changes. Between them, similarities, differences and indicators are in two major reasons (1) both concepts are defined and used in many different ways to achieve a variety of political goals possibly without reflecting their core definitions, and (2) both concepts share similar goals such as a focus on climate

While a development strategy is not sustainable if it is not resilient. Therefore, the two concepts are intertwined and cannot be successful individually as they are dependent on one another. Resilience focuses on the design for unpredictable, while sustainability focuses on the climate responsive designs. Some forms of resilience such as adaptive resilience focus on designs that can adapt and change based on a shock event, on the other hand, sustainable design focuses on systems that are efficient and optimized.

Resilience, the ability of a system to prepare for threat, absorb impacts, recover and adapt following persistent stress or a disruptive event or the capacity to recover quickly from difficulties and toughness.

Sustainability, the ability to be maintained at a certain rate or level and avoidance of the depletion of natural resources in order to maintain an ecological balance, is a social goal for people to co-exist on Earth over a long time.

1.3 Artificial Intelligence (AI)

High-profile applications of AI include advanced web search engines (e.g., Google Search); recommendation systems (used by YouTube, Amazon, and Netflix); virtual assistants (e.g., Google Assistant, Siri, and Alexa); autonomous vehicles (e.g., Waymo); generative and creative tools (e.g., Chat GPT and AI art); and superhuman play and analysis in strategy games (e.g., chess and Go). However, many AI applications are not perceived as AI: "A lot of cutting edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it's not labeled AI anymore. "Artificial intelligence was founded as an academic discipline and the field went through multiple cycles of optimism throughout its history, followed by periods of disappointment and loss of funding, known as AI winters. Funding and interest vastly increased after 2012 when graphics processing units started being used to accelerate neural networks, and deep learning outperformed previous AI techniques. This growth accelerated further after 2017 with the transformer architecture. In the 2020s, an ongoing period of rapid progress in advanced generative AI became known as the AI boom. Generative AI's ability to create and modify content has led to several unintended consequences and harms, while raising ethical concerns about AI's long-term effects and potential existential risks, prompting discussions about regulatory policies to ensure the safety and benefits of the technology. (Luger, George; Stubblefield, William, 2004)

II. LITERATURE REVIEW

2.1 Coronavirus disease 2019 (COVID-19)

The symptoms and severity of severe special infectious pneumonia vary from person to person. There are people who are infected without symptoms.Most patients with symptoms have mild symptoms (about 81%). Most patients present with flu-like symptoms. Fever is the most common symptom of severe specific infectious pneumonia, which may be high or low fever. Most patients will have a fever at some stage. Most patients also have a cough, which may be a dry cough or a productive cough.Other common clinical manifestations include fatigue, weakness in the limbs, shortness of breath, nasal congestion, muscle and joint pain, sneezing, runny nose, coughing up blood, and sputum. About 40% of patients experience loss of smell and taste, or other interference with normal sense of smell or taste. This symptom generally appears in the early stages of the disease. Some mild patients do not have pneumonia symptoms, but only have low-grade fever and mild fatigue. Severe symptoms include difficulty breathing, persistent chest pain, confusion, difficulty walking, or blackening of the face and lips.Severe complications include acute respiratory distress syndrome (ARDS), septic shock, systemic inflammatory response syndrome (SIRS), irreversible metabolic acidosis, acute myocardial injury, coagulation disorders, and even death.The incubation period is usually about 4-5 days after exposure, but is generally thought to be no longer than 14 days. 97.5% of patients develop symptoms within 11.5 days of infection. It is currently believed that asymptomatic patients are capable of transmitting the disease.The initial spread of the epidemic may have originated from wild animals to humans, and later human-to-human transmission became the main route of transmission. Severe specific infectious pneumonia is mainly transmitted through droplets from patients coughing or sneezing. In addition to direct inhalation of droplets from patients, it may also be transmitted by touching surfaces contaminated by droplets and then touching the face (environmental contamination transmission model).

Air transmission is an effective way to spread the virus, usually occurring in crowded, poorly ventilated indoor spaces, especially in gatherings such as restaurants, nightclubs, public transportation, and funerals.Sputum and saliva carry large amounts of the virus. Although severe specific infectious pneumonia is not a sexually transmitted disease, kissing and close contact can spread the virus. The virus may be present in breast milk, but it is not clear whether it can be transmitted to infants.

2.2 Sustainability and Resilience

Experts often describe sustainability as having three dimensions (Fig.1): environmental, economic, and social, and many publications emphasize the environmental dimension. In everyday use, sustainability often focuses on countering major environmental problems, including climate change, loss of biodiversity, loss of ecosystem services, land degradation, and air and water pollution.

From the view point of the similarities between resilience and sustainability will be: (1) Keeping consistence between human society and the natural environment is possible; (2) Focusing on the topics of social & ecological systems; climate change impacts; globalization and community or livelihood development is the common targets; (3) Pursuing system survivability, security & well-being is the goals (See Table 1).

While the ideal segments between resilience and sustainability can be done from their purposes, such as Table 2. The adoption indicators between sustainability and resilience are based on the means to achieve the goals (see Table 3)

SUSTAINABILITY is best defined as "to meet the needs of the present without compromising the ability of future generations to meet their own needs". Net Zero carbons are a cornerstone of sustainability, recycled materials offer another sustainable strategy. Green building certifications like indicate the level of sustainability of a building that reduces its negative impact on the environment.

RESILIENCE in the context of building structures and communities refers to the ability to continue functioning or recover quickly in the face of some chronic or sudden external failure such as water shortage,
power outage, or a natural disaster. Resilience instead refers to the ability of a building or environment to achieve self-sufficiency. Efficiency would refer to the ability to use resources with minimal waste, while resilience would refer to being able to produce or maintain resources internally. Think of resilience as an **MITIGATION** strategies for buildings and communities commonly refer to avoiding risks in the construction/development stage, as well as reducing or eliminating potential hazards for the future (Per Frez Wagner ,2009), indicator of how well a system responds to shock and recovers from natural hazards or human-induced threats. (Fig. 2)

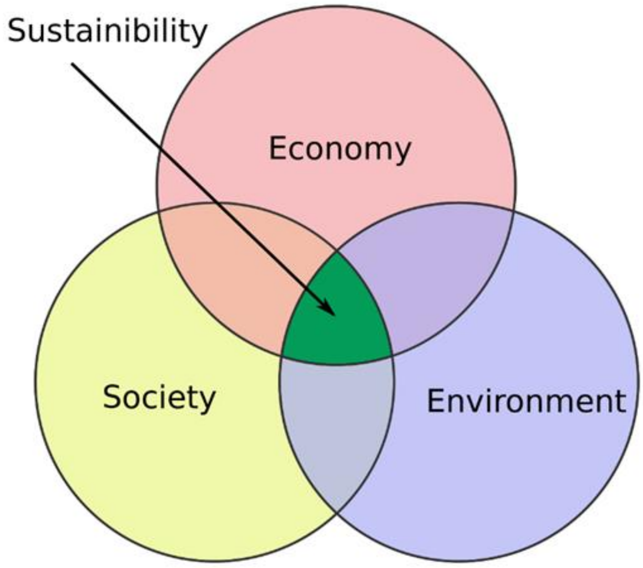


Fig. 1 Three Dimensions of Sustainability

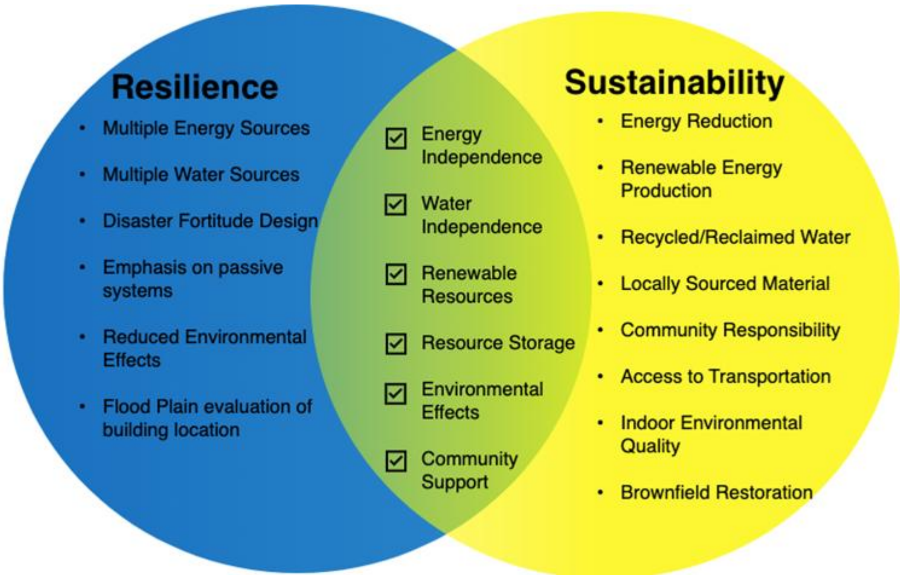


Figure 2. Resilience versus Sustainability and the United Nations goals. Adapted from Echotape (2018)

Table 1. Similarities between Sustainability and Resilience

Assumptions	Harmony between Human Society and the Natural Environment is Possible
Research Focus	Social & Ecological Systems; Climate Change Impacts; Globalization; Community Development
Methods	Climate Change Policies & Actions, especially Governance; Education and Learning as an Implementation Tools
Goals	System Survivability, Security & Well-being (Social & Biodiversity); Sense of Place & Belonging (Heritage)

Source: Alan Lew& Tsung-Chiung Emily Wu (2016)

Table 2. Differences between Sustainability & Resilience

	Sustainability	**Resilience**
Assumptions	Stability & Balance	Unpredictable Change &Chaos
Goals	Normative Ideals on Culture,Economic Environment Conservation;	Strategic, Dynamic and Self-organizing on Systems, culture and Learning Institutions with Innovation
Research Focus	Environmental & Social Impacts of Economic Development; Over use of Resources; Carbon Footprints	Natural & Human Disaster Management; Climate Change Impacts
Methods	“Wise Use” Resource Management; Mitigating or Preservation Against Change; Recycling & “Greening”; Education for Behavior Change	Reducing Vulnerability & Increasing Physical & Social Capacity for Change (flexibility, redundancy); System Feedback& Performance; Education for Innovation

Source: as Table 1 with some modifications.

ADAPTATION in the context of buildings was explained as “a range of construction activities that improveexisting building conditions and extend the effective lives of buildings. so become entrained at nearly equal discharges. The interaction between mitigation and adaption is expressed in Fig. 3.

Table 3. Adoption Indicators of Sustainability and Resilience

Category	**Sustainability Indicators**	**Resilience Indicators**
Local Government Budgeting	***Conserving***environmentalResources –with protection & restoration	***Building***Capacity for Change on Level of infrastructureconstruction& resource access with Innovation for marketing
Environmental Knowledge	***Maintaining Traditional Resource***of local environmental knowledgeand traditional practices	***Creating New Environmental Knowledge*** of Participationin environmental education programs to Innovating the traditional knowledge
Community Well Being	***Preserving*** Cultural & Traditions by based on natural resource to strengthenthe traditional livelihoods.	***Improving***Living Conditions & Employment to Rate of unemployment & youth outmigration

Social Support Systems	***Providing*** Social Welfare & Equity to Support elderly & underprivileged populations	***Supporting***Social Collaboration to rateof participation in religious & other local organizations

Source: as Table 1 with some modifications.

2.3 Artificial Intelligence (AI)
The general problem of simulating (or creating) intelligence has been broken into subproblems. These consist of particular traits or capabilities that researchers expect an intelligent system to display. The traits described below have received the most attention and cover the scope of AI research.

1. Reasoning and problem-solving:
Early researchers developed algorithms that imitated step-by-step reasoning that humans use when they solve puzzles or make logical deductions. Methods were developed for dealing with uncertain or incomplete information, employing concepts from probability and economics.

2. Knowledge representation:
Knowledge representation and knowledge engineering allow AI programs to answer questions intelligently and make deductions about real-world facts. Formal knowledge representations are used in content-based indexing and retrieval, scene interpretation, clinical decision support, knowledge discovery (mining "interesting" and actionable inferences from large databases), and other areas. A knowledge base is a body of knowledge represented in a form that can be used by a program. An ontology is the set of objects, relations, concepts, and properties used by a particular domain of knowledge. Among the most difficult problems in knowledge representation are the breadth of commonsense knowledge (the set of atomic facts that the average person knows is enormous); and the sub-symbolic form of most commonsense knowledge (much of what people know is not represented as "facts" or "statements" that they could express verbally). There is also the difficulty of knowledge acquisition, the problem of obtaining knowledge for AI applications. (Russell, Stuart J.; Norvig, Peter, 2021)

3. Planning and decision-making:
An "agent" is anything that perceives and takes actions in the world. A rational agent has goals or preferences and takes actions to make them happen. In automated planning, the agent has a specific goal. In automated decision-making, the agent has preferences—there are some situations it would prefer to be in, and some situations it is trying to avoid. The decision-making agent assigns a number to each situation (called the "utility") that measures how much the agent prefers it. For each possible action, it can calculate the "expected utility": the utility of all possible outcomes of the action, weighted by the probability that the outcome will occur. It can then choose the action with the maximum expected utility. A Markov decision process has a transition model that describes the probability that a particular action will change the state in a particular way and a reward function that supplies the utility of each state and the cost of each action. A policy associates a decision with each possible state. The policy could be calculated (e.g., by iteration), be heuristic, or it can be learned.Game theory describes the rational behavior of multiple interacting agents and is used in AI programs that make decisions that involve other agents.

4. Learning:
Machine learning is the study of programs that can improve their performance on a given task automatically.It has been a part of AI from the beginning. In reinforcement learning, the agent is rewarded for good responses and punished for bad ones.Computational learning theory can assess learners by computational complexity, by sample complexity (how much data is required), or by other notions of optimization. Transfer learning is when the knowledge gained from one problem is applied to a new problem.Deep learning is a type of machine learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning. (Vincent, James, 2019).

5. Natural language processing:
Natural language processing (NLP) allows programs to read, write and communicate in human languages. Specific problems include speech recognition, speech synthesis, machine translation, information extraction, information retrieval and question answering. Modern deep learning techniques for NLP include word embedding (representing words, typically as vectors encoding their meaning), transformers (a deep learning architecture using an attention mechanism), and others. In 2019, generative pre-trained transformer (or "GPT") language models began to generate coherent text, and by 2023, these models were able to get human-level scores on the bar exam, SAT test, GRE test, and many other real-world applications. (Bushwick, Sophie, 2023).

6. Perception:

Machine perception is the ability to use input from sensors (such as cameras, microphones, wireless signals, active lidar, sonar, radar, and tactile sensors) to deduce aspects of the world. Computer vision is the ability to analyze visual input.
The field includes speech recognition, image classification, facial recognition, object recognition, object tracking, and robotic perception. (Scassellati, Brian, 2002).

7. Social intelligence:
Affective computing is a field that comprises systems that recognize, interpret, process, or simulate human feeling, emotion, and mood. For example, some virtual assistants are programmed to speak conversationally or even to banter humorously; it makes them appear more sensitive to the emotional dynamics of human interaction, or to otherwise facilitate human–computer interaction. (Waddell, Kaveh, 2018; Poria, Soujanya; Cambria, Erik; Bajpai, Rajiv; Hussain, Amir, 2017).
However, this tends to give naïve users an unrealistic conception of the intelligence of existing computer agents. Moderate successes related to affective computing include textual sentiment analysis and, more recently, multimodal sentiment analysis, wherein AI classifies the effects displayed by a videotaped subject.

8. General intelligence:
A machine with artificial general intelligence would be able to solve a wide variety of problems with breadth and versatility similar to human intelligence.

III. THEORETICAL CONSIDERATION AND METHODOLOGIES

3.1 Coronavirus disease 2019 (COVID-19)

3.1.1 Prevention

In the absence of a vaccine, other preventive measures or effective treatment, a key part of managing severe pneumonia is to try to reduce and delay the peak of the epidemic, also known as "flattening the curve" (Roy M Anderson et, al. 2020). This means taking various measures early in the epidemic to delay the peak of the epidemic, reduce the infection rate to reduce the risk of health services being overwhelmed, enable existing cases to be better treated, and delay more cases until effective treatments or vaccines become available.Preventive measures to reduce the chance of infection include: staying at home and not going out; wearing a mask in public places; avoiding crowded places; keeping a distance from others; washing hands frequently with soap and water (especially after coughing, sneezing, before and after eating, after going to the toilet, and after contact with live animals and other risky activities), and avoid touching the eyes, nose and mouth with unwashed hands.When coughing or sneezing, you should cover your mouth and nose with a tissue or your bent elbow, then throw the used tissue in a designated place and wash your hands effectively; avoid close contact with anyone with suspected symptoms such as fever or cough; maintain good respiratory hygiene; avoid eating raw or undercooked animal products; and avoid touching your eyes, nose or mouth with unwashed hands.Patients with early clinical symptoms should wear standard masks to reduce the chance of infecting others and be isolated for observation. An experiment published in Nature showed that in an environment without masks, droplet transmission such as sneezing exhibits multi-stage turbulence, and most tiny droplets are difficult to settle. It is suggested that medical workers should wear additional protective measures such as goggles when diagnosing suspected and confirmed cases.

3.1.2 Vaccine

The SARS vaccine is designed to provide acquired immunity against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19.Prior to the COVID-19 pandemic, there was an established body of knowledge about the structure and function of coronaviruses that cause diseases such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). This knowledge accelerated the development of a variety of vaccine platforms in early 2020. SARS-CoV-2 vaccines initially focused on preventing symptomatic, often severe disease. In January 2020, SARS-CoV-2 genetic sequence data were shared via GISAID, and by March 2020, the global pharmaceutical industry announced major commitments to address COVID-19.In 2020, the first COVID-19 vaccines were developed and made available to the public under emergency authorization and conditional approval. Initially, most COVID-19 vaccines were two-dose vaccines, with the only exception being a single-dose COVID-19 vaccine. However, it was found that the immunity provided by the vaccines waned over time, requiring people to receive booster doses of the vaccine to remain immune to COVID-19.

3.1.3 Personal Hygiene and Social Distancing

1. Hand hygiene:
According to the recommendations of the U.S. Centers for Disease Control and Prevention, daily hand washing should last for more than 20 seconds, using soap and other cleaning products in between. Hand washing should be done promptly after going to the toilet, before eating, and whenever you cough or sneeze. The use of hand sanitizer with an alcohol content of more than 60% is also recommended. The World Health Organization advises the public to avoid touching the mouth, nose, eyes and other susceptible parts of the body without washing their hands. The World Health Organization recommends the use of 80% ethanol and 75% isopropyl alcohol disinfectants, both of which are based on glycerol, based on the criteria of rapid onset of action and broad spectrum of inactivation of microorganisms. These disinfectants have been shown to effectively reduce the titers of viruses such as SARS-CoV and MERS-CoV. For in vitro SARS-CoV-2 viruses, disinfectants containing 80% ethanol or 75% isopropyl alcohol have also been shown to effectively inactivate the virus.
2. Respiratory Hygiene:
Health agencies around the world recommend covering the mouth and nose with the elbow or disposable tissue when coughing or sneezing, and disposing of the tissue immediately. At the same time, medical masks or N95 masks are recommended for use by vulnerable groups to limit the spread of virus-carrying aerosols produced when talking, coughing, and sneezing. The World Health Organization has issued relevant guidance on the scenarios and time of mask use.
3. Personal protection:
Medical professionals need to take more precautions when implementing treatment. Diseased aerosols may appear during intubation or the use of emergency bags. Therefore, public health agencies such as the Centers for Disease Control and Prevention in the United States recommend that medical staff wear protective clothing, masks or respirators, goggles, and gloves when caring for SARS-CoV-2 carriers before performing relevant medical operations.
4. Maintain social distance:
Social distancing (also known as physical distancing) is a non-pharmaceutical infection control measure that attempts to slow the spread of disease by reducing contact between infected and uninfected people. Methods include quarantines, travel restrictions, perimeter quarantines, cancellation of large gatherings, and closures of schools, workplaces, stadiums, theaters, and shopping malls. Individuals can practice social distancing by staying at home, limiting travel, avoiding crowded places, using non-contact greetings, and physically keeping distance from others.
5. Ventilation and air filtration:
Ventilation and air filtration in public places can help dilute and remove potentially infectious aerosols.

3.1.4 Treatment

Preliminary results from a UK clinical trial suggest that the corticosteroid dexamethasone may be effective for critically ill COVID-19 patients, the first time a drug has been shown to be so effective in a trial. In patients on ventilators, treatment with the drug has been shown to reduce mortality by about a third, and in patients who only require oxygen, it has been shown to reduce mortality by about a fifth. The treatment was effective only in patients with severe disease, and did not help patients with milder disease. Dexamethasone is already in use in the UK National Health Service (NHS). The drug works by suppressing the body's immune system, calming its overreaction in an attempt to fight the virus.Previously, supportive treatment was mainly provided by monitoring and maintaining the patient's vital signs, providing timely and effective oxygen therapy, respiratory therapy such as ventilators, and infusions, and supporting the affected organs The Centers for Disease Control and Prevention (CDC) in the United States recommends that suspected cases should wear surgical masks. Extracorporeal membrane oxygenation (ECMO) has been used to maintain the vital signs of patients with respiratory failure, but its actual effectiveness remains to be evaluated. The World Health Organization (WHO) and the National Health Commission of China have made recommendations for patients hospitalized with severe COVID-19.Some clinicians consider acetaminophen or nonsteroidal anti-inflammatory drugs (NSAIDs) to be the first line of treatment. Although some have hypothesized that NSAIDs may make the condition worse, the U.S. Food and Drug Administration (FDA) has concluded that there is insufficient evidence to support this view. The European Medicines Agency and the World Health Organization both agree that these drugs should be used when necessary.

3.1.5 Prognosis

COVID-19 symptoms range from milder cases with symptoms similar to those of common upper respiratory tract illnesses to more severe cases that take three to six weeks to recover. Although children are also susceptible, most have milder symptoms and are less likely to develop severe disease than older adults.Patients with lymphocytopenia or acute renal injury have a poorer prognosis. Elevated liver function indexes, elevated lactate dehydrogenase, elevated inflammatory indexes (such as C-reactive protein, ferritin, etc.), D-dimer, prolonged prothrombin time, or elevated creatinine in the blood can also be considered indicators of a poor prognosis.

1. Complications:
Complications may include pneumonia, acute respiratory distress syndrome (ARDS), multiple organ failure, septic shock, and death.Cardiovascular complications may include heart failure, arrhythmia, myocarditis, and thrombosis.About 20-30% of COVID-19 patients have elevated transaminases, reflecting liver damage.Neurological manifestations include seizures, stroke, encephalitis, and Guillain-Barré syndrome (including motor loss). Following infection, children may develop pediatric multisystem inflammatory syndrome, which has symptoms similar to Kawasaki disease and can be fatal. In rare cases, acute encephalopathy may occur.
2. Long-term effects:
Some early studies suggest that 5 to 10 people with COVID-19 experience symptoms that last for more than a month. Most patients hospitalized with severe illness have long-term problems, including fatigue and shortness of breath. There are also reports of so-called brain fog after COVID-19 infection, described as cognitive impairments such as "difficulty concentrating" and "memory loss."
3. Immunity:
As with most other infections, the human immune response to the SARS-CoV-2 virus is a combination of cell-mediated immunity and antibody production. As SARS-CoV-2 has only been known to humans since December 2019, it is not yet clear whether immunity remains long-lasting in patients who have recovered from the disease.The presence of neutralizing antibodies in the blood is closely associated with protection against infection, but levels of neutralizing antibodies decrease over time. Some asymptomatic or mildly ill patients have undetectable neutralizing antibody levels two months after infection.In another study, neutralizing antibody levels dropped fourfold between one and four months after symptom onset. However, the absence of antibodies in the blood does not mean that antibodies will not be rapidly produced upon re-exposure to SARS-CoV-2. Memory B cells specific for the spike protein (S protein) and nucleocapsid protein of SARS-CoV-2 persist for at least six months after symptom onset.However, there have been 15 reports of reinfection with SARS-CoV-2 using the CDC's strict criteria. If reinfection is common, herd immunity will not be able to eliminate the virus.

3.2 Sustainability and Resilience with Artificial Intelligence Applications

3.2.1 In term of Resilience

A. Disaster prediction and response: AI can analyze data such as climate, earthquakes,
and epidemics to predict disasters and assist in developing response plans.
B. Supply chain resilience: AI can monitor supply chain risks in real time, predict disruptions, and propose alternatives to enhance the resilience of companies and cities.
C. System simulation and stress testing: Through digital twins, AI can simulate extreme scenarios to help organizations prepare in advance.

3.2.2 In term of Sustainability

A. Energy and resource optimization: AI can help companies and cities optimize energy use, reduce waste and carbon emissions.
B. Environmental monitoring: AI can analyze satellite images and sensor data to track
deforestation, water pollution and biodiversity changes.
C. Sustainable innovation: AI can accelerate the development of green technologies, such as carbon capture technology and renewable energy system design.
D. Policy and reporting support: AI can assist companies with ESG reporting, sustainable performance tracking and regulatory compliance.
In the AI-driven future, engineers are no longer just “people who write programs”, but multi-faceted talents who can collaborate with AI, solve complex problems, and create value. According to observations from the World Economic Forum and many technology companies, the following are the new skills that engineers of the future must have. In order to stand out in the AI-driven era, future engineers need to develop a new set of skills in addition to traditional professional knowledge. This is not just about "learning to use AI", but "collaborating with AI and amplifying their own value". Here are a few key skills:

Technical aspects:
1. Prompt Engineering
Being able to write precise instructions so that AI tools can produce results that meet the needs has become the "programming language" of the new era.
2. AI tool application ability
Be familiar with AI programming auxiliary tools such as Copilot, ChatGPT, Cursor, and can effectively integrate them into the development process.
3. Data literacy and analysis ability
Be able to understand the meaning behind the data and use AI models for prediction, optimization and decision-making.

4. System architecture and review ability
AI can write programs, but it cannot replace humans in the design and risk assessment of the overall architecture. Knowing how to review AI output and ensure quality and safety is the core task of future engineers.
5. DevOps and automated process design
Be familiar with CI/CD, containerization (such as Docker), cloud deployment and other skills to improve development efficiency.

Soft power and cross-domain capabilities
1. Cross-domain communication skills:
Engineers are no longer just "people who write programs", but must be able to work with product, design, and business teams to understand business needs and propose technical solutions.
2. Creative thinking and problem-solving skills:
AI is good at pattern recognition, but innovation and breakthroughs still rely on human intuition and imagination.
3. Lifelong learning and adaptability:
Technology changes rapidly, and only by having the ability to "learn how to learn" can you avoid being eliminated by the times.
4. Ethics and sense of responsibility:
The application of AI involves privacy, bias, and social impact. Engineers need to have basic technological ethical judgment.
5. Technological ethics and risk awareness:
Understand the bias, information security and social impacts that AI may bring, and make responsible decisions.
The World Economic Forum also predicts that analytical thinking, resilience, creativity, technological literacy and empathy will be the most important workplace skills in 2025.

IV. Research Issues and Analysis Results

4.1 From the perspective of sustainability and resilience, how should we face and solve century-wide influenza problems such as COVID-19?

On the view point of the perspective of sustainability and resilience, responding to the century-old influenza challenge of COVID-19 requires not only short-term medical response, but also a systematic, cross-sector long-term strategy. The following are several key aspects and practical directions:
A. Sustainability: Building a long-term stable social and environmental foundation
1. Triple Bottom Line: Policies and actions must take into account the environment, society and economy at the same time, to avoid focusing only on economic recovery while ignoring social equity and ecological protection.
2. Sustainable investment in the health system: Strengthen primary healthcare, vaccine research and development, and public health infrastructure to ensure a rapid response to future epidemics.
3. Green Recovery: Direct post-pandemic economic stimulus packages toward low-carbon transformation and ecological restoration to avoid repeating the same environmental destruction.
4. Social equity and inclusion: The pandemic has exposed the vulnerability of disadvantaged groups, and sustainable development must incorporate social justice and inclusive policies.
B. Resilience: Strengthening the system's ability to predict, absorb, and recover
1. The three elements of organizational resilience: anticipation, robustness, and recoverability are the core capabilities of enterprises and governments in facing crises.
2. Digital transformation and data-driven decision-making: Use AI, big data and machine learning to predict epidemic trends, optimize resource allocation and supply chain management.
3. Distributed supply chain and localization: Reduce dependence on a single source and improve the flexibility and responsiveness of the supply chain.
4. Community resilience building: Strengthening the autonomous response capabilities of local governments and communities, such as community health watch and local food systems.
C. Integration strategy: Build Back Better from the crisis.
The OECD proposed the concept of "building back better", emphasizing that post-epidemic recovery should not just return to the past, but turn to a more sustainable and resilient development model. This includes:

Strategic Direction Description

1.Ecological prosperity	1. Reduce over-dependence on natural resources and promotea circular economy
2.Decarbonization Economy	2. Accelerating energy transition and carbon neutrality goals
3.Fair governance	3. Establish a transparent and participatory decision-making mechanism

4.Public trust 4.Strengthen trust and cooperation between the government and the public
5. Fair burden 5. The allocation of epidemic costs and recovery resources must take into account the vulnerable

D. Applications:
Here are some examples of how several countries combined sustainability and resilience to manage and recover from the COVID-19 pandemic. These strategies not only addressed the current crisis, but also built more robust systems for the future:
(A). New Zealand: Governance resilience based on trust and transparency
1. Rapid lockdown and zero-clearance strategy: Strict border control and community lockdown were adopted in the early stages to successfully suppress the spread of the virus.
2. Prime Minister communicates in person: Jacinda Ardern uses empathy and transparency to build public trust and improve policy compliance.
3. Social inclusion policies: Provide rent subsidies, wage subsidies and mental health resources to reduce the impact on vulnerable groups.
4. Sustainable recovery: Promote green infrastructure and low-carbon transportation, and combine economic stimulus with climate action.
(B). South Korea: A model of digital resilience and social collaboration
1. Digital contact tracing system: Combines mobile phone location, credit card records and CCTV to quickly track the infection chain.
2. Public-private collaboration: Companies quickly scale up mask and test kit production, and the government coordinates distribution.
3. Social participation: Citizens voluntarily comply with epidemic prevention regulations, and community organizations assist in the distribution of supplies and care for elderly people living alone.
4. Green transformation: Promote the "Korean version of the New Deal" after the epidemic and invest in renewable energy and digital infrastructure.

(C).Germany: Institutional resilience and the coordination of federal governance
1. Strengthen public health institutions: The Robert Koch Institute provides scientific advice and data support.
2. Federal and local coordination: Each state adjusts measures based on the epidemic situation, and the central government provides resources and guidance.
3. Social safety net: The short-term work subsidy (Kurzarbeit) system reduces unemployment and business failures.
4. Sustainable medical investment: expand ICU capacity, improve medical staff benefits, and enhance long-term medical resilience.

(D). Taiwan: Integration of social capital and digital governance:
1. The health insurance card integrates mask distribution and vaccine reservations: the digital system improves efficiency and fairness.
2. Community epidemic prevention network: local clinics, pharmacies and community organizations jointly participate in epidemic prevention.
3. Information transparency and citizen trust: Daily press conferences and real-time information releases reduce panic and rumors.
4. Post-epidemic policy: Promote "One Health" and long-term care system reform to enhance future resilience.
(E)International Observation: The intersection of COVID resilience and SDGs
According to the Bloomberg COVID Resilience Ranking and SDG Index, most of the top performing countries have the following characteristics:

Resilience characteristics Description
1. High social trust1. High policy compliance and transparent information
2. Improve the public 2. Rapid expansion and adaptation
medical system
3. Digital governance3. High efficiency in information integration and resource capabilities allocation
4. Green recovery 4. Combining economic stimulus with sustainable
Orientation development
(F) Comparison between Taiwan and China:
From the intersection model of "sustainability × resilience × epidemic response", we can explore the situation in Taiwan from the following two perspectives:
1. Taiwan:

(1) Scenario Modeling (Sustainability × Resilience × Pandemic Response):
This part can extend the original intersection model and add Taiwan's local challenges and advantages:

- Sustainability indicators: energy transition (promotion of solar energy), water resource management (such as water conservancy and reservoir regulation) and social inclusion (indigenous peoples and rural health care).
- Resilient structure: including central and local health command systems (CDC, local health bureaus), digital governance platforms (such as the 1922 SMS messaging system), and civil society participation.
- Experience in responding to the epidemic: From the lessons of SARS to the rapid action of COVID-19, the real-name system for masks and the vaccination platform are both examples of institutional resilience.

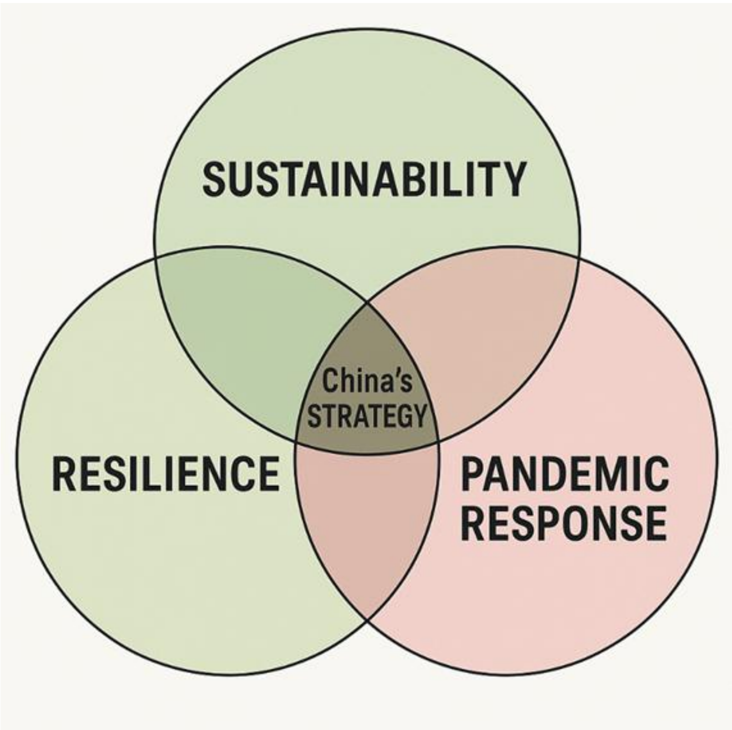
(2)Policy Evaluation Framework Design:
A structured framework can be developed to help governments or research teams assess whether a strategy has all three elements:

a. Facets:Sustainability.
Evaluation Dimension:Long-term impact, Resource Efficiency, Fairness.
Indicator Examples:GHG emission changes, Energy self-sufficiency rate, Social satisfaction.

b. Facets:Resilience.
Evaluation Dimension:Response speed, Adaptability, and Institutional flexibility
Indicator Examples:Policy implementation timeliness and Cross-departmental collaboration index.

c. Facets:Epidemic Response.
Evaluation Dimension:Readiness, Communication control, Resource allocation
Indicator Examples:PCR testing rate, Vaccine coverage, and Redundancy of medical resources

2. China:



Here is a specific international case comparison: Peking University's Chen Songqi team conducted a quantitative analysis of the epidemic response strategies of 25 countries and found that China and South Korea were the most successful in terms of response speed and policy intensity during the first wave of the epidemic. If other countries adopt similar strategies, they can reduce the number of confirmed cases by 91% and the number of deaths by 88% on average.However, the study also pointed out that although China's "lockdown" and forced isolation are effective, they are difficult to replicate in democratic countries because they involve challenges in human rights and social acceptance. This is the core tension at the intersection of "sustainability × resilience × epidemic response": how to respond to the crisis quickly and effectively while maintaining social trust and human rights.

4.2 Even sustainability and resilience are closely related in the epidemic management, what are the differences of their core concepts, goals, and practices?

The following is a systematic analysis of their differences and relevance:

A. Sustainability: Designing systems for long-term stability and fairness

Topic	*Explanation*
1. Focus items	1. Environmental protection, social justice, and economic stability (Triple Bottom Line)
2. Epidemic application	2.Establish a fair and accessible medical system, strengthen public health infrastructure, and promote green recovery policies
3. Time scale	3.Long-term (strategic, intergenerational)

Example: Promoting the "One Health" policy to integrate human, animal and environmental health into overall planning.

B.Resilience: the ability to respond and recover immediately from shocks

Topic	*Explanation*
1. Core goals	1. Enhance the system's ability to absorb, adapt and recover from emergencies.
2. Focus items	2. Anticipation, Robustness, Recoverability.
3. Epidemic application	3. Rapid establishment of testing and vaccine distribution systems, digital contact tracing, supply chain adjustments.
4. Time scale	4.Short- to medium-term (tactical, operational).

Example: South Korea used digital technology to quickly trace infection chains, demonstrating a high level of social and technological resilience.

C. The link between sustainability and resilience: complementary rather than Contradictory. Sustainability × Resilience: Complementary and Integrated Governance Strategies

Topic	*Explanation*
1. Resilience is the foundation of sustainability	1. Without resilience, the system cannot withstand shocksand naturally cannot be sustainable in the long term.
2. Sustainability is the direction of resilience	2. Resilience without a sustainable orientation may only enhance short-term recovery while ignoring long-term equity and environmental costs.
3. Common goal	3. Improve system adaptability and inclusiveness, reduce future risks and inequality.
4. Strategic integration	4. OECD advocates "Build Back Better": rebuilding a more resilient and sustainable society from the crisis.

Simple metaphor:

Sustainability is like designing a house that can be lived in for a hundred years, taking into account climate, energy and housing equity;

Resilience refers to whether the house can stand still and be repaired quickly when Anearthquake strikes.

United Nations SDG 11 clearly states that cities and human settlements should be "includingsafe, resilient and sustainable".

D. The differences between Taiwan and China on the topics of "sustainability ×resilience × epidemic management", or further explore the empirical research onESG (environment, society, governance) and corporate resilience:

The model of Sustainability × Resilience × Epidemic Management has a core of the intersection is social trust, institutional flexibility, and resource allocation. At the intersection of the three, the key challenge is how to maintain social trust in a crisis, flexibly adjust institutions, and effectively allocate resources without sacrificing long-term sustainable goals.

1. In Taiwan:

(1) Highlights of Empirical Research:
- According to research by National Tsing Hua University and National Taiwan Normal University, Taiwanese companies' performance in the corporate governance (G) and environment (E) dimensions can significantly reduce extreme risks (such as the maximum decline in stock prices).
- The social dimension (S) had a relatively weak impact during the epidemic, but the governance dimension showed a high degree of resilience during the crisis.

(2) Policy Implementation:
- The "mask real-name system" and "vaccine reservation platform" during the epidemic period demonstrate the resilience of digital governance.
-ESG report disclosure obligations will be expanded from 2023 to strengthen corporate sustainability transparency.

2. China:
(1) Highlights of Empirical Research:
- Using A-share listed companies from 2009 to 2022 as a sample, the study shows that ESG performance is positively correlated with corporate resilience.
- Corporate governance (G) has the most significant impact on improving resilience, especially in an environment of high policy uncertainty.
- Digital transformation and financial constraints have positive and negative moderating effects on the ESG-resilience relationship, respectively.

(2)Policy Implementation:
- China launched ESG guidelines in 2022. Although disclosure is voluntary, large companies have gradually established ESG committees and reporting mechanisms.
- The "health code" and "lockdown policy" during the epidemic period demonstrated high-intensity governance resilience, but also triggered social acceptance and human rights disputes.

4.3 If you encounter COVID-19 or other century-old influenza problems during construction, how should you deal with and solve them?

When encountering COVID-19 and other century-old flus at construction sites, in addition to basic epidemic prevention responses, it is also necessary to establish a sustainable and adaptable construction management mechanism from the perspective of sustainability and resilience. The following are specific countermeasures that integrate domestic and foreign practices and policies:

A. Resilience Strategies for Construction Sites:

1. Strategies:Manpower scheduling flexibility
Practical approach:Establish a cross-training system for multiple trades to avoid work stoppages caused by key personnel being infected.
2. Strategies:Zoning construction and diversion management
Practical approach:Divide the construction site into independent areas to reduce cross-contact between personnel
3.Strategies:Digital Site Management
Practical approach:Introducing BIM, IoT, remote monitoring and paperless approval to reduce on-site staff density
4.Strategies:Construction period risk management
Practical approach:Pre-set epidemic shutdown scenarios, incorporating CPM criterion analysis and contract flexibility clauses
5. Strategies:Supply Chain Resilience
Practical approach:Diversified material sources, advance material preparation, and local procurement reduces the risk of logistics disruption

B. Sustainability-oriented construction management

1. Management:Health and Safety Sustainability
Practical approach:Set up well-ventilated rest areas, provide psychological support resources, and strengthen PPE equipment
2. Management:Care of foreign workers
Practical approach:Providing quarantine space, health monitoring, and epidemic

prevention information in friendly languages
3. Management:Green construction
Practical approach:Reduce construction carbon emissions, use low-volatile building materials, and promote resource recycling
4. Management:Social Responsibility
Practical approach:Work with local communities to establish communication and coordination mechanisms during the epidemic

C. Policy and regulatory support (Taiwan as an example):
Based on the recommendations of the Public ConstructionCommittee and Lee and Li Attorneys-at-Law, the government has formulated a number of response measures:
1. Construction extension mechanism:During the epidemic period, you can apply for an extension based on "non-attributable reasons", and there is a standardized calculation method (for example, during the Level 3 alert period, it can be extended by 1/2 day).
2. Principle of formal review: During the epidemic period, manufacturers can register and declare labor shortages, and the agency will conduct a formal review based on the principle of good faith to reduce the burden of proof.
3. Flexible contract adjustments: Changes and cost compensation can be made in accordance with Point 49 of the Purchase Contract Essentials and Article 7 of the Project Contract Template.

D. International Learning: Engineering Resilience Practice:
1. Nation:Singapore
Practical approach:Establish a "construction site bubble" system to provide centralized accommodation and separate construction areas for workers
2. Nation:Japan
Practical approach:Introducing AI site monitoring and remote inspection to reduce on-site manpower
3. Nation:Germany
Practical approach:Public works contracts include a "force majeure" clause to protect the rights of manufacturers

4.4What services can AI provide for this century-long flu problem like COVID-19?
In dealing with COVID-19 and other century-old influenza, AI has demonstrated its potential for cross-domain integration and efficient response. The following areseven core services that AI can provide in epidemic management, covering prediction, prevention, medical treatment, governance and social aspects:
1. Epidemic Forecast and Risk Warning:
(1)Flu forecasting models: For example, the “Flu Forecasting Station” jointly developed by the Taiwan Centers for Disease Control and Prevention and Acer uses machine learning to predict epidemic trends in the next four weeks, with an accuracy rate higher than the international average.
(2)Multi-source data fusion: Combine weather, population mobility, social media and drug sales data to predict epidemic hotspots and spread speed.
(3) AI simulation of virus evolution: such as Meta’s EpiSim tool, which can simulate epidemic development scenarios under different policies.
2. Smart Medicine and Clinical Assistance:
(1)AI-assisted diagnosis: Analyze chest X-rays and CT images to help determine whether it is a COVID-19 infection.
(2) Telemedicine and chatbots: Provide initial symptom assessment, health consultation and medical advice, reducing the pressure on medical institutions.
(3) Accelerate drug and vaccine research and development: AI can simulate protein structure, screen candidate drugs, and significantly shorten the research and development process.
3. Public health governance and resource allocation:
(1) Smart contact tracing: For example, South Korea combines mobile phone positioning with CCTV to quickly track infection chains.
(2) Optimal allocation of medical resources: AI assists in the scheduling of ICU beds,

ventilators, and manpower to improve response efficiency.

(3) Community risk grading management: Dynamically adjust epidemic prevention levels and restriction measures based on real-time data.

4. Strengthening supply chain and logistics resilience:

(1)AI predicts material needs: such as masks, vaccines, testing reagents, etc., to avoid shortages or waste.

(2)Smart delivery and contactless logistics: Combining autonomous vehicles, drones and AI scheduling to improve delivery efficiency and safety.

5. Digital Communication and Risk Perception;

(1)Social media analysis: Real-time monitoring of false information and public sentiment, and assisting the government in adjusting its communication strategies.

(2) Multilingual risk communication platform: enhance the understanding and response capabilities of vulnerable groups to epidemic information.

6. Personalized health management and prevention:

(1)Smart Health Assistant: Provides vaccination reminders and protection recommendations based on personal living habits, geographic location and genetic information.

(2)Wearable device integration: Track changes in body temperature, heart rate and breathing to detect potential infection risks early.

7. Decision Support and Simulation Sandbox:

(1)Policy scenario simulation: AI can simulate the impact of policies such as city lockdowns, vaccine distribution, and school openings, helping the government make scientific decisions.

(2)Human-machine collaborative governance: Combining AI predictions with expert judgment to improve decision-making transparency and credibility.

V. Summaries

A. The specific meanings of sustainability and resilience in epidemic management areas follows:

In epidemic management, sustainability and resilience are not just abstract concepts, but concrete and actionable governance principles. They represent "long-termstability" and "short-term shock response" respectively, but they are inseparable in practice. The following are their specific meanings and application levels in epidemic management:

Sustainability: Building a long-term, stable and fair epidemic prevention system

Topic Specific meaning and practice

1. Sustainability of medical 1. Invest in primary healthcare, vaccine development, resourcesand public health infrastructure to ensure sustainable response to future epidemics

2. Social justice2. Ensure that vulnerable groups (such as migrant workers, the elderly, and low-income households) have fair access to medical care and subsidies.

3. Economic and3. Post-epidemic economic recovery should lead to a environmental balance green transformation, avoiding "retaliatory carbon emissions" and excessive resource consumption.

4. Institutionalized4. Incorporate epidemic prevention into normal policies Governanceandregulations, and establish cross-departmental collaborationand transparent decision-making mechanisms.

For example: The EU has launched a "Green Recovery Plan" to combine epidemic relief with climate action.

Resilience: Strengthening the system's immediate response and resilience to sudden outbreaks.

TopicSpecific meaning and practice

1. Prediction and early 1. Establish epidemic monitoring system and AI model to warning capabilitiespredict transmission trend

2. Rapid response 2. Establish crisis response teams, conduct simulation mechanismexercises, and flexibly dispatch medical and logistics resources.

3. Supply Chain and 3. Distributed supply chain and localized production to avoid Logistics Resiliencematerial chain disconnection

4. Community and 4. Local governments and communities canindependently

Organizational initiate epidemic prevention measures, such as community Resiliencehealth watch and mask distribution system.

For example,South Korea has demonstrated high resilience through digital contact tracking and community collaboration.

B.How to enhance resilience in epidemic management under climate change:

In an era where climate change and global health risks are intertwined, pandemic resilience is no longer just a medical issue, but a systemic challenge across domains and scales. ***The following are five strategic directions compiled from international research and policy practices to strengthen pandemic resilience under climate change:***

1. Integrate climate and health risk assessments:

(1) Develop a climate × health risk map: Combine climate simulations (e.g. RCP/SSP scenarios) with disease transmission models to identify high-risk areas (e.g. spread of tropical diseases, increased air pollution).

(2) Promote the One Health framework: Integrate human, animal and ecosystem health into the same governance structure to prevent cross-species diseases caused by climate change (such as emerging zoonotic diseases).

2. Building a resilient healthcare system:

(1) Strengthening primary care and telecare: Maintaining access to healthcare in extreme climates, especially in rural and elderly communities.

(2) Climate-adaptive design of medical facilities: such as flood protection, backup energy, ventilation and cooling systems to ensure continued operation during disasters.

(3) Vaccine and drug supply chain resilience: Promote localized production and diversified supply sources to avoid logistics disruptions caused by climate disasters.

3. Digital Governance and Early Warning System:

(1) AI epidemic prediction model: combines climate data and epidemiological parameters to predict epidemic outbreak hotspots and time windows.

(2) Smart monitoring systems: Deploy IoT sensors and satellite data to monitor climate change and the activities of vectors such as mosquitoes.

(3) Multilingual Risk Communication Platform: Enhance the understanding and response capabilities of vulnerable groups on climate and health risks.

4. Nature-based Solutions (NbS)

(1) Green infrastructure: such as urban green space and wetland restoration to reduce urban heat island effect and the breeding of disease vectors.

(2) Water resource resilience management: ensuring safe drinking water supplies during droughts and floods and preventing the spread of waterborne diseases.

(3) Food security and nutritional adaptation: Climate change affects agricultural production, and the diversity and localization of food systems need to be strengthened.

5. Multilevel governance and social participation:

(1) Local autonomous adaptation capabilities: such as community health watches, local epidemic prevention drills, and climate health education.

(2) Inter-departmental collaboration mechanism: integrating resources and actions from health, environment, agriculture, education and other departments.

(3) International cooperation and knowledge sharing: Participate in platforms such as WHO, UNFCCC, GCA, etc. to learn from other countries' adaptation experiences as followings:

International Case Highlights

1. Nation:Netherlands
   Resilience Strategy: Incorporating climate adaptation into COVID-19 recovery plans
   Effectiveness:Improve epidemic prevention and water resource management capabilities at the same time.
2. Nation:Kenya
   Resilience Strategy: Local Climate Fund supports community health initiatives
   Effectiveness:Improving the resilience of rural areas to climate change and epidemics
3. Nation:Bengal
   Resilience Strategy:Establishing an integrated climate and health data platform
   Effectiveness:Improve disease early warning and resource dispatch efficiency

C. By considering the causes and prevention methods of COVID-19, how can AI effectively provide strategies for sustainability and resilience in engineering construction and in response to future climate change?

That's a brilliant systems-level question, and it's right in your wheelhouse of integrating public health, engineering, and environmental governance. Let's unpack how AI can bridge lessons from COVID-19 into actionable strategies for sustainable and resilient construction, especially in the face of climate change:

1. Lessons from COVID-19: Causes & Prevention

(1) Causes: Zoonotic spillover, global mobility, and urban density accelerated transmission.

(2) Prevention: Surveillance, contact tracing, remote work, and adaptive infrastructure were key.

These responses revealed vulnerabilities in supply chains, labor availability, and infrastructure adaptability—insights that AI can now leverage.

2. AI Strategies for Sustainable & Resilient Construction

(1) Digital Twin Technology:

- Simulates construction environments to test resilience against pandemics or climate events.
- Enables predictive maintenance and energy optimization.

(2) Smart Supply Chain Management:

- AI can forecast disruptions (like those seen during COVID-19) and reroute logistics.
- Enhances material sourcing with sustainability metrics (e.g., carbon footprint, recyclability).

(3) Remote Monitoring & Automation:

- Reduces on-site labor needs during crises.
- Improves safety and continuity using drones, robotics, and IoT sensors.

(4) Climate-Adaptive Design:

- AI models can simulate climate scenarios (heatwaves, floods) to inform resilient architecture.
- Supports selection of low-impact materials and passive design strategies.

(5) Policy & Risk Modeling:

- AI can analyze epidemiological and climate data to guide urban planning and building codes.
- Helps governments prioritize infrastructure investments based on resilience scoring.

3. A recent study from the SASBE 2024 conference highlights how digital Constructionhelped mitigate COVID-19 disruptions while advancing sustainability goals. Byintegrating remote work, digital project management, and energy-efficient design,firms improved both resilience and environmental impact.

Here comes our visual framework—sketched to show how AI strategies interconnect across pandemic resilience and climate adaptation. Now let's dive deeper into two domains you highlighted:

(1) AI in Water Infrastructure

AI is transforming water systems to be more climate-resilient and equitable:

- **Hydrological Forecasting**: LSTM and hybrid physics-informed neural networks predict floods and droughts with high accuracy (NSE > 0.90).
- **Smart Distribution**: AI-driven optimization improves water delivery efficiency by 15–30%.
- **IoT Integration**: Sensors detect leaks and monitor agricultural water use, reducing waste by up to 40%.
- **Ethical Governance**: Decentralized data ecosystems and explainable AI (XAI) help build trust and empower underserved regions.

Challenge**:** 70% of AI applications are concentrated in temperate, data-rich regions—leaving arid and low-income areas behind.

(2)AI in Green Energy Retrofits

Retrofitting buildings for energy efficiency is critical—and AI is making it smarter:

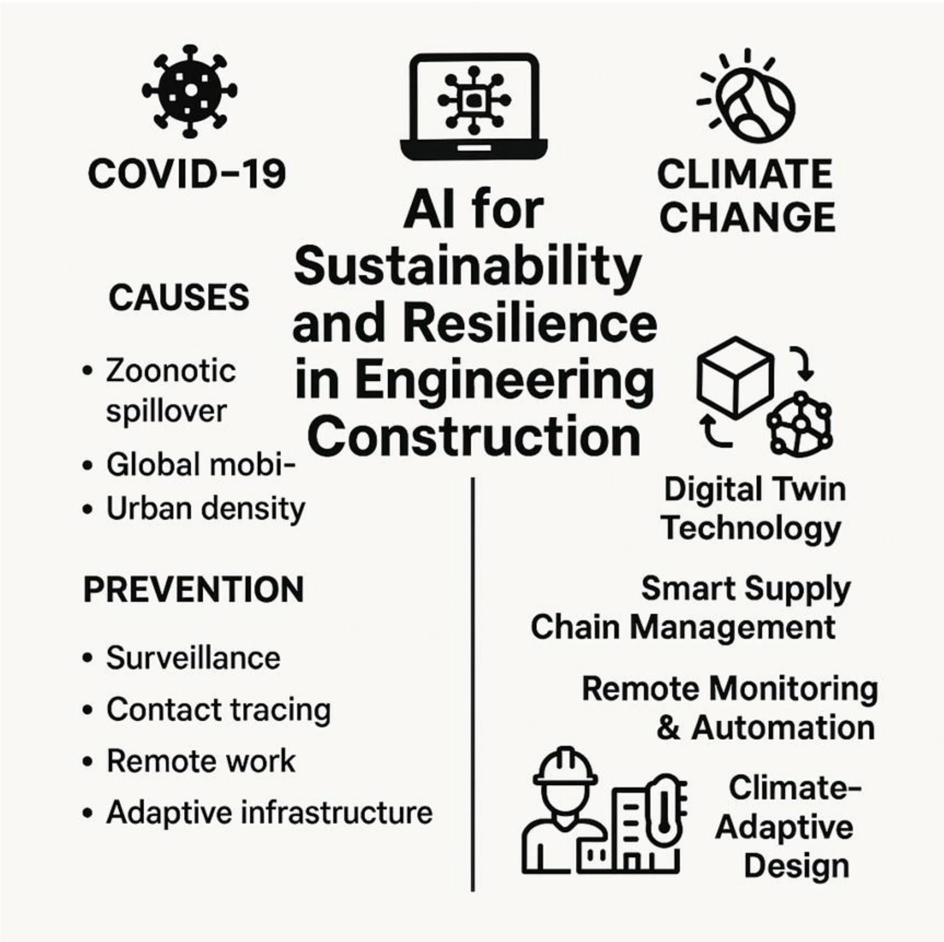
- **Predictive Modeling**: AI simulates retrofit outcomes using real-world data, reducing uncertainty and improving accuracy.

- **Explainable AI (XAI)**: Tools like SHAP identify key building features that influence retrofit success, enhancing transparency.
- **Synthetic Data Generation**: CTGAN models overcome data scarcity by creating realistic training data for retrofit recommendations.
- **Decision Support Systems**: AI helps policymakers prioritize retrofit actions based on energy savings and climate impact.

Impact: AI-enabled retrofits can significantly reduce emissions and energy costs, especially in aging building stocks.

4. I explore how these strategies could be integrated into a national resilience roadmapor applied to a specific region of Taiwan.

(A) How can we measure the effectiveness of these AI application?
(B)How will the government give the helps?
(C)Finally, what innovative technologies can hence AI in these domains?



(A) Integrating AI into Taiwan's National Resilience Roadmap

1. Strategic Integration:

Taiwan's government is already advancing 10 major AI projects focused oninfrastructure, smart applications, and emerging tech like quantum computing. **To align with resilience goals:**

- Water Infrastructure: Embed AI into flood forecasting, leak detection, and smart irrigation systems.
- Green Energy Retrofits: Use AI to optimize building energy use, forecast renewable output, and guide retrofitting decisions.

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--Regional Customization:for areas like Taichung City or Nan-tun District:

- Leverage local climate and infrastructure data to train AI models.
- Deploy IoT sensors for real-time monitoring of water and energy systems.
- Partner with universities and tech hubs to pilot AI-driven retrofits in public buildings.

--Measuring Effectiveness of AI Applications

<u>Key Metrics</u>

Domain	Metric Type	Example Tools/Methods
Water Infrastructure	Forecast Accuracy, Leak Reduction	LSTM models, IoT sensors, RF classifiers
Green Energy	Energy Savings, Carbon Reduction	SHAP analysis, CTGAN synthetic data
Governance Impact	Policy Responsiveness, Equity Index	XAI dashboards, scenario simulations

- **Cross-efficiency benchmarking** (e.g., DEA models) can compare AI systems by environmental cost vs. performance.
- **Hybrid AI models** offer better adaptability and interpretability for water consumption forecasting.

--Government Support in Taiwan

Taiwan's government is actively enabling AI adoption through:

- **Funding**: NT$100 billion allocated via the National Development Fund for AI transformation across industries.
- **Infrastructure**: Free GPU resources and AI prototype production lines to support startups.
- **Talent Development**: AI literacy programs for civil servants and partnerships with Taiwan AI Academy.
- **Water Sector Training**: The Water Resources Agency reports successful AI integration into operations and staff development.

--Innovative Technologies Enhancing AI in Water & Energy

<u>1. Water Domain</u>

- **Taiwan AI Water Alarm Network**: Predictive alerts for water resource protection.
- **Waste LCD Recycling**: Recycled glass used as adsorbents in wastewater treatment.
- **Smart IoT Pollution Traceability**: Tracks environmental contaminants in real time.

<u>2. Energy Domain</u>

- **TSMC's AI-Powered Chiller System**: Machine learning models optimize compressor loads and pressure control, saving 100M kWh annually.
- **Intelligent Building Energy Management Systems (IBEMS)**: Used in retrofitted campuses to halve energy intensity.

D. Regarding "climate change × epidemic management × resilience strategy", we will analyze the specific practices and policy evolution of Taiwan and China respectively. We will also build a cross-domain strategic blueprint. The core of the intersection of climate change × epidemic management × resilience strategy is system integration, risk early warning, resource scheduling, and social trust.

(A) Policy Evolution and Specific Practice

1. In Taiwan:

<u>Policy evolution:</u>

-- Amendment to the Climate Change Response Act (2023): Add a chapter on adaptation to strengthen local government responsibilities and cross-departmental collaboration.
-- Climate Change Science Report 2024: Incorporate risk assessment, early warning mechanisms, and identification of adaptation hotspots.
-- Resilience of the epidemic management system: Real-name system for masks, vaccine reservation platform, and 1922 SMS real-time connection system demonstrate digital governance capabilities.

Specific practices

-- Water resource resilience: Promote recycled water, underground water, andsmart dispatch systems to strengthen water supply backup.
-- Health resilience: Establish a health early warning system under extremeclimate and strengthen the prevention and control of heatdamage and cold waves.
-- Social participation: Incorporate citizen opinions and indigenous knowledge into the public hearing system and local adaptation plans.

2. In China

Policy evolution:

-- White Paper on China's Policies and Actions on Climate Change (2021): Proposes a three-axis strategy of carbon peak, carbon neutrality and resilient governance.
-- Annual Report 2024: Incorporates carbon market construction, nature-based solutions (NbS) and global governance participation.
-- Epidemic management strategy: Health codes, lockdown policies and digital tracking systems demonstrate high-intensity governance resilience

Specific practices

-- Manufacturing resilience: Strengthen supply chain risk management and infrastructure climate resilience after floods.
-- Energy system: Promote green and low-carbon transformation, and strengthen flood risk assessment of power grids and power plants.
-- Global participation: Actively participate in COP29 and advocate a fair and reasonable climate governance framework.

(B) Strategic blueprint and Interactive forms: cross-domain resilient integration architecture:

1. Institutional resilience:
   Taiwan characteristics: Local Adaptation Action Plan, Public Hearing System.
   Chinese characteristics: White Paper Policy Framework, CentralizeScheduling.
2. Technology application:
   Taiwan characteristics: Smart water network, epidemic early warning platform.
   Chinese characteristics: Health code system, flood risk model.
3. Social Participation:
   Taiwan characteristics: Civic engagement and integration of indigenous knowledge.
   Chinese characteristics: Social mobilization and digital surveillance go hand in hand.
4. International Links:
   Taiwan characteristics: Participating in IPCC, emphasizing local adaptation and global responsibility
   Chinese characteristics: Participate in COP29 and advocate for a global governance framework.
5. Nature-Based Solutions NbS:
   Taiwan characteristics: Wetland conservation, urban greening, stormwater management
   Chinese characteristics: Coastal dynamic balance, ocean carbon sink monitoring.

(C) Policy evaluation tool: three-axis intersection scoring model:

1. Sustainability:
   Indicator Examples: GHG emission changes, energy self-sufficiency rate, social satisfaction

Comparison: Taiwan is slightly higher than China (7:6)

2. Resilience: Policy implementation timeliness and cross-departmental collaboration index
Comparison: Taiwan is slightly lower than China (8:9)
3. Epidemic Response:
Indicator Examples: PCR testing rate, vaccine coverage, and redundancy of medical resources
Comparison: Taiwan is slightly higher than China (9:8)

(D) Design Phase Integration Suggestions:
1. Modular design: Incorporate five modules (institutional, technological, social, international, and natural) into the policy toolkit.
2. Scenario simulation: Establish a compound risk simulation platform of "extreme climate × epidemic outbreak".
3. Cross-departmental collaboration mechanism: Design a “Resilient Governance Workshop” and a “Policy Sandbox” system to promote co-creation between ministries and local governments.

E. To analyze in depth the technical architecture and examples of AI applications inthe following areas: predictive modeling, smart healthcare, or supply chain management.

(A) AI prediction model: epidemic and risk warning

1. Technical architecture

-- Data source integration: combining heterogeneous data from multiple sources such as hospital bulletins, social media, traffic flow, and weather data.
-- Algorithm model:
o Time series analysis (such as Prophet, ARIMA)
o Machine learning (such as XGBoost, Random Forest)
o Deep learning (such as LSTM, Transformer)
-- Simulation and scenario analysis: The SEIR infectious disease model can be combined to perform policy scenario simulation.

2. Example:

-- BlueDot (Canada): Through NLP and global news monitoring, it warned ofCOVID-19 in late 2019.
-- Google × Harvard Health Research Institute: Develop a public COVID-19 prediction model to predict ICU utilization and demand for epidemic prevention supplies.
-- China Centers for Disease Control and Prevention × Smart Eye Migration System: combines LBS and AI models to track epidemic transmission paths and high-risk groups.

(B) AI Smart Healthcare: Clinical Assistance and Zero-Contact Care:

1. Technical architecture

-- Medical image recognition: Use CNN models to interpret X-ray, CT, and MRI images.
-- Generative medical record system: Combines NLP and speech recognition to automatically generate nursing records and diagnosis summaries.
-- Telemedicine platform: integrating IoT sensors, video systems and AI analysis modules.

2.Example:

-- Changhua Hospital in Taiwan: Introducing AI medical record generation and contactless measurement systems to reduce clinical burdens.
-- AI medical imaging diagnosis: The accuracy rate of COVID-19 image recognition is 90%, and the degree of disease progression can be determined in real time.
-- Smart epidemic prevention self-service machine: combines thermal photography, identity recognition and real-time reporting to improve the efficiency of epidemic prevention in hospitals.

(C) AI Supply Chain Management: Resilience Prediction and Resource Scheduling

1. Technical architecture

--Demand forecasting model: Combine sales history, weather, and social trends to make multi-variable forecasts.

-- Risk Awareness System: Analyze supplier financial, geographic and political risks and create a supply chain risk map.

-- Smart logistics and warehousing: Using computer vision and IoT instruments for route optimization and inventory management.

2. Example:

-- H2O.ai ×混合雲平台：協助企業即時預測供應鏈中斷風險並制定轉型策略。

-- Gartner survey: By 2024, 50% of supply chain leaders plan to introduce generative AI for resilience enhancement.

-- Application in Taiwan's manufacturing industry: Introducing AI predictive maintenance and multi-supplier analysis to enhance disaster resilience.

(D) AI prediction model: epidemic and public health risk warning:

1.Technical architecture

--SEIR × AI hybrid model: Combine the infectious disease SEIR model with machine learning algorithms (such as LSTM, XGBoost) to predict epidemic trends.

--Integration of multi-source data: integrating population migration, social media, medical reports and policy intervention data.

-- Scenario simulation engine: can simulate epidemic rebound or relief scenarios based on policy changes (such as lockdown intensity).

2. Example:

-- Zhong Nanshan Team × Wingzhun Smart Healthcare: Established a COVID-19 prediction model and successfully predicted the peak of the epidemic and the impact of policy delays.

-- PandemicLLM (developed by Chinese students): uses a large language model (LLM) to integrate policy texts, genetic monitoring, and spatiotemporal data to provide three weeks advance warning of an epidemic rebound.

(E) AI Smart Healthcare: Clinical Assistance and Health Management

1.Technical architecture

-- Medical image recognition system: Use CNN models to interpret CT and X-ray images.

-- Cloud platform integration: Introducing Azure, Power BI and other platforms for genetic analysis and medication monitoring.

-- Federated Learning Framework: Collaboratively train AI models across institutions to protect data privacy.

2. Example:

--China National Medical University × Microsoft Azure: Introducing AI medical record analysis and Power BI dashboard to successfully save patients in the intensive care unit.

-- The 14th Five-Year Plan promotes AI+ smart healthcare: the market size will reach RMB 9.55 billion in 2021, and the CAGR is expected to be 40% in 2026.

-- 2030 Universal Smart Health Management Model: It is expected to integrate AI nutritionists, virtual psychology courses and sensory technology for disease management.

(F) AI Supply Chain Management: Resilience Prediction and Resource Scheduling

1.Technical architecture

-- Digital supply chain platform: Integrating IoT sensors, computer vision and AI predictive models

-- Risk Awareness System: Analyze supplier financial, geographic and political risks and create a risk map.

-- Smart logistics module: Use AI for route optimization and inventory management.

2. Example:

-- JD × Midea × SAIC: The three companies introduced AI to enhance the resilience of the supply chain and establish intelligent platforms and digital warehousing systems.

-- IEK report analysis: China's supply chain policy focuses on digitalization and industrial Internet to promote the transformation of small and medium-sized enterprises.

-- Generative AI × LLM application: Use natural language to interact with LLM for supply chain planning and risk forecasting.

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