STEM Fellowship Journal

Fair Housing: A Blueprint for Equity in Life: Proceedings from the 2022-2023 High School Big Data Challenge

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In the STEM Fellowship High School Big Data Challenge, students have the opportunity to engage in independent research projects and acquire fundamental data science skills – an essential skill set for a young researcher in the digital age. The program is inquiry-driven and experiential.

This year, we invited students to explore issues of Fair Housing at the Individual and Community Levels and to suggest their own evidence-based solutions, using Open Data and the principles of Open Science. Students explored many topics, ranging from a New Framework for Public Rental Housing in Toronto to A Statistical Analysis on Thawing Permafrost and Its Effects on Housing.

We designed in-depth learning modules for students as a means of bridging the gap between traditional high school courseware and digital reality and computational science. Students learned how to uncover hidden patterns and trends in structured and unstructured data using a range of data analytics tools and programming languages. Python, R, LaTeX, and machine learning were some of the tools the students learned and used.

On behalf of the STEM Fellowship, we extend our sincere congratulations to all students who participated in the challenge, and wish them the best for their future endeavours. We want to express our appreciation to all the mentors and volunteers. This program would not be possible without patronage of CC UNESCO and generous support of our sponsors: RBC Future Launch, Let's Talk Science, Digital Science, Infor, SCWST, CISCO Networking Academy, Canadian Science Publishing, and the University of Calgary Hunter Hub for Entrepreneurial Thinking.

We were privileged to witness first-hand the analytical capabilities of the data-native generation of students, and we are confident they will demonstrate excellence throughout their academic and professional careers.

Yoojin Lee
Project Management Team Lead

Dr. Sacha Noukhovitch
President and Editor-in-Chief
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Disclaimer

These abstracts are provided for all student teams that have submitted project reports by January 15, 2023. The STEM Fellowship Journal editorial board has made every effort to ensure proof and English editing of these abstracts in a limited amount of time, and neither organization as a whole or any of its volunteer members can be held accountable for inaccuracies that may have occurred in the abstract publication. Abstracts are published in no particular order.

Enhancing HVAC design using smart home technologies

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Today, HVAC is not efficient nor effective at filtering airborne viruses in the air. With COVID-19 and viral pandemics being a significant porion of our new everyday lives, it is important we look into the future. Using the data we have collected, it is clear that COVID-19 cases and energy efficiency have a clear correlation. However, Carbon Monoxide (CO) pollution has no relationship to energy efficiency as much of it is caused by fossil fuels rather than a lack of HVAC support. As a solution, we can incorporate smart home technologies to assist HVAC in filtering airborne viruses.

Analyzing parks within urban areas in the United States to see connection with health

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The prevalence of and proximity to park space within urban areas has been viewed as important from a variety of different sources, as seen within Goal 11.7 of the Sustainable Development Goals (SDG). Specifically, the prevalence of parks has been shown to affect the health of people who live nearby, through improvement of mental well-being, increased physical activity and lowered levels of pollution. To assess this relationship, linear and multivariate regressions were run to compare how various park and spending indicators within the United States compared to health factors, such as depression, obesity, and physical health. These regressions were compared against both R2 values and significant F values. By increasing park area, medical spending in these areas could be reduced, in addition to the expected benefits that come from an improvement of health. These issues could especially help in low-income neighbourhoods and with residents of colour, since they are more likely to be severely under served by parks in comparison with their wealthier or white counterparts. Creating these spaces for urban dwellers will improve equity in terms of places where people can live and grow.

The influence of a house's proximity to amenities on educational attainment and demographic in the U.S

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As worldwide urbanization continues with more neighborhoods being constructed, identifying important factors for a high-functioning neighborhood is becoming more relevant. A house's proximity to amenities has been extensively studied in relation to housing prices, but little with other success factors due to granular data limitations. We present an analysis of the relationship between a house's proximity to amenities – including but not limited to grocery stores, healthcare, schools and gyms – and demographic and educational metrics in cities across the United States. To estimate the relation, 1630 stratified samples of houses were selected. For each house, amenity data was collected via the Geoapify API and a proximity score is calculated. After analyzing them vis-à-vis educational and demographic data, we drew conclusions such as the proximity to amenities has a positive correlation with Bachelor's degree attainment and lower-valued areas have less access to amenities. In addition, amenities are distributed equally among areas with households below the poverty line and more rich amenity cities are found amongst cities with high diversity. These findings can inspire changes in fair housing and city planning, for example, the construction of amenities like schools may help achieve educational attainment.

Inflation: How does inflation affect fair housing?

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The purpose of this study is to identify how inflation affects fair housing. At this time, especially after the COVID-19 pandemic, inflation around the world has risen much too high for comfort. Many would think that buying a home would be a feasible goal, however, as real estate prices and demand has risen after the world has gotten back on their feet, the vision of fair housing is fading out of reach quite quickly. The contents of this literature review explain the causes and

effects of inflation, including its definition as well as its effect on Canada's Housing Market through reliable websites and papers. This study will pursue our research question, 'How does Inflation affect fair housing?'. We argue that fair housing needs to be implemented soon through a dependable solution as homeownership is becoming more difficult for the average individual. Overall, we believe that the goal is to determine the effects of inflation on fair housing and what can be done against it.

A statistical analysis on thawing permafrost in Canada's North and its effects on housing

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Thawing permafrost has been exacerbated by the effects of climate change and lack of action. With an estimated permafrost loss of 40% by the end of the century, northern Canadian regions, which are home to over 120,000 residents, are becoming increasingly vulnerable to its numerous consequences. This report explored the ecology behind permafrost and the environmental and infrastructure implications of thaw both long and short term. A statistical analysis using python data visualization was used to explore permafrost patterns in southern Yukon and Northwest Territories. Data science, scholarly research, and expert outreach were employed for a holistic overview. The report used open-access data from the NERC Environmental Information Data Centre to analyze the soil temperature, soil depth, thaw depth, and its correlation to infrastructure vulnerability. Google Colaboratory was used to perform statistical analysis and the chosen language was python. Pyplot and pandas were used to import and graph the raw data for data visualization. The data, in the form of CSV files, were cleaned using tokenism, stemming, and other functions. Statistical analyses were used to ensure the significance of this research. Scholarly research was performed using electronic databases on Nature, Sustainability, ScienceDirect, Jstor, and Proquest. A discussion was made based on the findings presented to conclude the urgency of the issue from a range of perspectives, possible solutions to mitigate the impacts of thawing permafrost on infrastructure, and future research steps.

An investigation of the housing market supply function

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As the global population rapidly approaches the carrying capacity of the logistic growth curve, safe and affordable housing (SDG 11) is crucial for the population's well-being. Apartments are one of the most affordable and accessible forms of housing, and thus, it is necessary to analyze the supply function of the apartment renting market. A significant portion of the housing supply derives from investors funding residential home-leasing companies. However, investors tend to underweight residential Real Estate Investment Trusts (REITs). This paper analyzes how the performance of Equity Residential, a leading apartment rental Real Estate Investment Trust Company (REIT) on the S&P 500, affects the housing market. The profitability (which in turn affects dividend yields for investors) of Equity Residential is a vital incentive for further funding and expansion of the residential housing sector to provide homes for more people. A thorough analysis of the company's balance sheet and income statement provides key insights into its liquidity, profitability, solvency, and its performance relative to the market. Understanding the residential real estate market and the performance of major companies in the industry will help policymakers generate incentives to provide more safe and affordable housing for all.

Investigating the impact of lower house prices, credit scores, average salaries, and debt to income on underrepresented people during economic recessions

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Although equitable housing for minorities has been a much-discussed topic in the past decade, it holds unique importance now due to the potential upcoming economic recession, which is especially concerning for minorities. With this in mind, our project seeks to investigate the impact of lower credit scores, average salary, and house prices—which

are proven to be particularly harsh on minorities—on racial minorities, ultimately predicting the real-world impact on wealth and home value. Our analysis primarily focused on the effects of the 2008 housing bubble burst and the COVID Recession and how it impacted individuals based on their race, in order to anticipate the exacerbated inequality in order to find solutions. Our project used Census Data from the United States government, modified and combined to our specific purposes. Ultimately, we were able to conclude that there is, indeed, a correlation between race and both lower home purchase prices as well as lower mortgage acceptance rates. Our model then established a clear connection to real-world quality-of-life indicators such as wealth and home value. This allows us to predict the changes in such indicators during the upcoming recession so that economists can find counteractive measures. For future research, it would be most beneficial to investigate different solutions and, once again, predict their respective impacts on wealth and home value in order to optimize economic situations during the recession.

An analysis on the correlations between socioeconomic factors and housing affordability

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In an ideal world, all citizens would have access to equitable housing. However, in Ontario, many individuals do not have such access. According to Canada's national housing agency, Canada Mortgage and Housing Corporation (CMHC), affordable housing refers to when a household's housing costs remain within 30% of their total income before tax [1]. Spurred by the rise of unaffordable housing and low-income residences in Ontario, our team decided to investigate the extent that the average income of a household correlates with the percentage of households with unaffordable housing. To assess the situation, we found data for countless communities across Ontario and their corresponding income levels, as well as factors such as population density and income levels, from the Government of Canada's 2021 Census. We highlighted correlations and trends in this dataset using Google Sheets and Python's diverse public libraries, ranging from numpy to geopandas, to create data representations ranging from choropleth maps to scatter plots. From our analysis, we discovered that income levels and shelter costs affect the affordability of dwellings in certain locations, whereas population density has little to do with affordability. We also discovered that renters, especially in areas of higher population, are disproportionately affected by unaffordable housing.

The differences between Toronto, Hong Kong and Singapore's housing market and identifying the factors that create these differences as well as its effect on home ownership rates and house prices in the three respective regions

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The housing market is a critical factor of the economy and in addition, is an important part of human life. All people need shelter of some kind, and it is provided through the housing market. In the past few years, with all the uncertainty in the globe, the housing market has seen significant change, and the direction it has been going in has not been encouraging for consumers. This paper will discuss the current state of the housing market in Toronto, Singapore and Hong Kong, identify which market is excelling/lacking and in what areas as well as what factors are driving these differences. The impacts of these differences will then be analyzed by looking at its effect on home ownership rates and house prices in the three respective regions. Analyzing the data collected through this research will allow us to identify which aspects of housing Canada has been doing well in and where it lacks in comparison to Hong Kong and Singapore.The data in this paper will be analyzed through Python using Pandas, NumPy, and scikit-learn to monitor trends. Findings from this paper can be used to suggest what affordable house prices should look like in Toronto, Singapore and Hong Kong.

Determining suitable geographic area for human settlement with machine learning

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Machine learning (ML), which sits at the nexus of computer science and statistics and at the centre of artificial intelligence (AI) and data science, is still developing at an accelerated rate due to its relative youth. The development of novel learning algorithms theory and the continual explosion in the accessibility of enormous amounts of data (commonly referred to as "big data") and low-cost processing have both been key drivers of recent advancements in machine learning (ML). In various fields of science, technology, and industry, such as healthcare, biomedicine, manufacturing, education, financial modelling, data governance, law enforcement, and marketing, the adoption of ML-based methodologies is encouraging more evidence-based decision making. In our project, we would be incorporating machine learning with geographic features to determine which unsettled area is optimal for human development and habitation. It would be approached by feeding in the program characteristics of good and bad geographic locations. The result would be given when we input an area's geographic features and the machine will determine whether it fits in the good geographic location section or the bad geographic location section.

Investigating the current policies to analyze the optimum solution for restoring the housing balance in Vancouver

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Canada has the least number of housing units per 1,000 residents among the G7 countries. In Canada, Vancouver has one of the lowest housing stocks per capita in the country, producing one of the lowest number of housing units in the world. With the increasing control over housing resources by the wealthy and the relatively slow increase in new construction, the number of people who demand better housing has increased by more than 20,000 over the past decade. The problem has to be solved with better policies without causing economic recessions from sharp drops in housing prices and investments. In addition, the persistent scarcity of dwellings triggers housing costs to rise, bringing concerns to citizens in Vancouver as their quality of living decreases. The paper aims to analyze the benefits and the drawbacks of four different solutions –expansion of affordable rental homes, decrease in investment development approval period, changes in taxing, and increase in mortgage rate– that can potentially allow housing market prices to become more affordable to a larger population in Vancouver. The elaboration of different solutions can only modify a small portion of the real estate market, as the increase of population(demand) always exceeds the time of construction (supply). The combination of these implementations can allow the market price to increase at a healthy rate, maximizing the resources in order to enhance the sustainability and livability of the city.

3D housing for Indigenous peoples

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As housing costs continue to rise in Canada, we see a rise in homelessness and inadequate housing in marginalized communities. To continue reconciliation with First Nation communities, our team has decided to investigxate the use of 3D printing to improve housing conditions while reducing costs. Research has been conducted to analyze the feasibility of scaling such processes to mass produce housing, when a report from IOP science showed that 3D printing had been implemented in various communities around the world. This project acknowledges the gap in knowledge about Indigenous communities, reserves, and their housing needs. To address this, our team will analyze large databases to identify the specific needs and priorities of these communities and compare it to the feasibility of scaling 3D printed housing. The investigation into 3D printing housing for Indigenous communities is significant, considering its potential wide scale impact on uplifting and strengthening these historically oppressed communities. 3D printing has allowed housing to become more affordable, which allows for the financial support of these Indigenous communities. It is also more timesaving to 3D print because each design modification can be completed at an efficient rate compared to regular manufacturing. Additionally, this method and material of housing is sustainable, durable, and biodegradable, which minimizes plastic waste and utilizes recyclable materials.

Racial and socioeconomic inequality in housing across Canada

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This study is about the various inequalities in housing caused by a variety of factors - age, gender, race, wealth, etc. This study contains a detailed analysis about each of these factors, and how we can best address these factors to make sure that Canada is a nation that is fair and just to all members of society, not just the advantaged. It contains the methods we used to reach that conclusion, and how we might have possibly reached a better one with an explanation as to why the data we measure/use may not be perfect due to the faults of the measurement methods. The authors explain these issues in detail, especially about the racial discrimination in housing and affordability vs race in certain neighbourhoods/ cities, and how the mental/physical health and standards of living in those neighbourhood is compared to the average.

Determining the role of government investment in housing in educational success

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Education is a powerful tool that allows one to develop their full potential and achieve financial stability. In society, housing plays a great role in a student's academic success; however, housing insecurity is a major issue that many Canadians face today. The goal of our study was to determine the impact of government investment in housing on education and quality of life in Canada. More specifically, we compared the investment in housing of several Cana- dian provinces to their Human Development Index (HDI) and average literacy and numeracy scores. We collected data on literacy, numeracy, and housing investment from Statistics Canada and data on HDI from Global Data Lab. Python language was used to sort and visualize the data in addition to identifying significant statistical correlations between our variables. We saw positive correlations between investment in housing and HDI, average literacy scores, and average numeracy scores. As housing investment increased, so did HDI, literacy, and numeracy. Unlike other papers, this paper stays within the scope of Canada, investigating housing investment and educational success in the country based on those three factors. Overall, this research paper offers compelling evidence that housing investment is an important factor in promoting educational success, highlighting the need for the government's continued attention to this issue.

GTA housing price and its correlations with socio-economic factors.

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House pricing, a volatile topic that the majority of the population would take into consideration at some point in their life. The purpose of this research is to examine the impact of different social events and identify the key significance that influences the tendency among the house market. In the project, we have dug in and conducted research on a range of variables that correlates causes and effects the house pricing in the Great Toronto Area. Early evaluations of this project through site visits and internet browser research; diversifying research keywords and channels are involved. Throughout the examination, we seek to define the factors with strong association with regards to the house pricing in the GTA.

COVID-19 and the housing market

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The COVID-19 pandemic has caused various perturbations to our world on multiple levels. The major interruptions to the world's economy and business activities have caused many problems to populations on an economical and social level. Especially within the housing market, the effects of the pandemic have caused many individuals and families to struggle paying their rents and the resulting inflation continues to decrease affordable housing. In this research paper, we explore several ways in which the COVID-19 pandemic has affected the economy which, in turn, has

taken a toll on the housing market. Our main objective is to analyze such factors and demonstrate how they can be linked to affordable housing, while also using the collected data to predict future trends. Analyzing the metrics used to assess the vitality of the housing market before the pandemic will yield a baseline from which to determine which factors impacted by COVID-19, were the most significant. By using data extrapolation and regression models, our group will analyze the short-term and long-term effects of the pandemic on housing. Thus, through our research, we have concluded that the pandemic has greatly affected the housing market and can be directly linked to its cost fluctuations resulting in a large amount of the population having trouble affording housing. Hence, as affordable housing continues to become less realistic for families, due to circumstances created by the pandemic, major inequalities within housing markets have become a daily struggle for billions around the World, as extravagant prices continue to rise.

The adoption of affordable housing projects in order to combat rising housing prices within Canada

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As housing prices in Canada have been steadily rising, it is no surprise that the average cost of housing far exceeds the average disposable income available to Canadian citizens. In fact, the rate at which housing prices have increased within Canada far exceeds that of any other developed market in the world, keying it the term 'shelter inflation'. The drastic price increase is forcing many more people to rent, and even those who are currently renting and could have bought a median priced home a year before, can not do so anymore. With this taken into account, it is all the more important that Canada adopts more affordable housing projects, with the goal of lowering housing costs within the country and making them more affordable. Over the past half-decade, many provinces throughout Canada have struggled to implement effective and sustainable affordable housing projects. Canada's most populous provinces such as Ontario, British Columbia, and Québec, have failed to reach their 2030 affordable housing targets as outlined by the Canada Mortgage and Housing Corporation (CMHC). Slow government action and labor shortages have contributed mostly to blame, and land developers lack the incentive to pursue sustainable housing projects due to the lack of profit. It is nearly impossible to create an adequate amount of affordable housing units through non-profits and subsidies, thus making it all the more important to derive alternative methods to lower the existing housing prices, while simultaneously setting more aggressive sustainable housing goals for the country.

Greenhouse gas emission induced thawing permafrost and its effects on housing safety

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In the 21st century, rising global temperatures are the leading cause of thawing permafrost [1]. This issue is especially significant in the Arctic, as over 66% of those settlements are located on permafrost [2]. Permafrost is any ground that is permanently frozen for two or more years [3]. Although permafrost on its own causes no harm to housing, the consequences of melted permafrost poses a great threat to human housing. When permafrost thaws, it reveals the weak, once frozen sediments in the ground. This weakened ground state can damage houses situated on top of permafrost, cracking the foundation and drywall of infrastructure [4]. It could also negatively impact the environment surrounding the house, including causing landslides or disrupting fresh water supplies [5]. This damage is amplified for isolated communities, who have limited access to resources. Our study found that the damage to communities will depend on the action we take on future greenhouse gas (GHG) emissions. Shared Socioeconomic Pathways (SSPs) are a series of climate projections that demonstrate the different scenarios of our future depending on our global temperature increase [6]. If emissions continue to rise as SSP5- 8.5 envisions, annual permafrost temperatures could reach -2.8°C. However, if we work together globally to control GHG emissions as SSP1-2.6 envisions, annual permafrost temperatures could decrease to -4.5°C. Therefore, to protect the future of communities in affected regions, more action should be taken to control and reduce GHG emissions. This study aims to investigate the relationship between the emissions of the major GHGs and the temperature of permafrost. By exploring this relationship, future hazards that pose a threat to human housing can be

better understood and mitigated.

Military housing availability and affordability: an analysis of the current state and potential solutions for improving housing for CAF service members and their families

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Those who fight for their country in the military should be held at the same standard of living as any other citizen. The issue becomes that military families have to move across Canada in order to be stationed near their assigned base. By moving frequently, it can have a strain on military families mentally, physically, and financially. This begs the question: is housing fair and accessible for families with members in the Canadian Armed Forces? This paper answers the question by looking at surveys and data related to the standard cost and housing distribution for veterans and current military families and other families in Canada over time. Using the Department of National Defence Housing's data on the number of houses available around Canada for members of the Canadian armed forces and the population of military members and their family members in each location, we can analyze whether the number of houses is enough for the population size. This information can also be utilized to see the relation between how much money the government is allocating to the Canadian armed forces and it is enough, and being put to good use. When this data was analyzed, it showed that there are not sufficient housing units allocated nor benefits provided to military families to aid in their living expenses. Using population representative surveys from 578 500 veteran families and total families in Canada upon living needs and satisfaction, as well as expenses such as tenure, costs, and affordability, a significant discrepancy between fairness for currently serving members of the Canadian Armed Forces and other families in Canada was found. The findings can help illustrate the current housing situation in Canada to be satisfying for the families who have access to residential housing units, yet a large population of military families do not have access to this facility. Housing for both military families and veterans is more inaccessible and unfair compared to the general population of Canada and needs to see change in funds to accommodate new and current military families.

Designing beautiful and appreciable architecture for all, including reflections of Indigenous cultures

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Appreciation of Indigenous culture requires one to understand the meaning and design behind their art. This research paper aims to identify key traits in Indigenous culture by examining their history and discovering how it is reflected in their architecture. We chose to study the Canadian Indigenous culture to demonstrate our learning from school. This will increase the appreciation for Indigenous architecture by revealing the meaning and history of every design. We first examined the history behind Indigenous culture to better understand their perspective when designing their architecture. To do this, we will find the percentage of all indigenous groups and display it in a pie chart. We will then find each of the group's unique architectural designs which will allow us to understand how the region impacts architecture. Next, we explored their religion and beliefs to see if that was reflected in their architecture. We will find all the major Indigenous religions and summarize them in a pie chart. Then, we will examine each religion and see how they affect each Indigenous group's architectural designs. Lastly, we considered the difference between their past and present living conditions to see how it changes their architectural style. We will summarize Indigenous people's living conditions and salaries to analyze their changes in lifestyle. By doing this, we can see how a change in lifestyle impacts their unique architectural designs. Through this research, we can fully value Indigenous architecture by knowing it insightful meanings.

An analysis of overpopulation and housing in Mumbai

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Mumbai is a highly overpopulated city in India with a rapidly growing population that has resulted in overcrowding and population density issues within the city centre and suburban district. Furthermore, due to Mumbai being India's largest commercial and industrial hub, the stability of the city must be preserved to prevent an economic crisis that could affect the country as a whole. In this report, an analysis of Mumbai's population distribution is performed. This report presents that most of Mumbai's population is heavily concentrated in the city centre with the lower income citizens residing in a series of sprawling slums that have taken root in the city's suburban districts, with the upper and upper middle classes living in the city centre. The heavy centralization of Mumbai's population may lead to disaster due to the severe risks of flooding during the rainy season of June to October. Additionally, significant portions of the city are at risk of sinking below sea level due to being situated on landfills created during the restructuring of the Isle of Bombay into the landmass where the city currently resides. Density regulations of Mumbai limit housing availability. This housing crisis has resulted in the prevalence of large squatter camps and slums. Without significant restructuring, Mumbai is at risk of a humanitarian crisis due to poor living conditions, overpopulation, environmental disaster, and a lack of housing. The solution to these issues would be incentive programs that distribute Mumbai's population to surrounding towns.

Addressing fair housing considering anthropogenic climate change-induced natural disasters

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Natural disasters are becoming more and more common, and they pose an increasing risk to numerous countries, millions of people, and billions of dollars of housing infrastructure. Addressing the problem of housing destruction caused by natural disasters is the first and major step towards the goal of fair housing. This study aims to analyse the impact of climate change on the damages created by natural disasters, and the effectiveness of current housing infrastructure against natural disasters. From this, we seek to investigate how housing infrastructure can be most effectively protected against future natural disasters, and how this information can help meet the goal of fair housing. Datasets acquired from the Centre for Research on the Epidemiology of Disasters' (CRED) Emergency Events Database EM-DAT were used to assess damages to housing infrastructure caused by a variety of natural disasters. This study employed statistical methods, namely linear regression, data comparison and visualization, in addition to decision trees to achieve the goals described above. Using these methods, it was found that housing infrastructure damage, correlated with a worsening of anthropogenic climate change, was projected to increase with time, creating a predicted $51 billion USD in damages in studied regions. Furthermore, methods calculated that damage-prevention procedures resulting in a difference of around 5 ft from the base flood level had highest efficiency in protecting houses from damages due to flooding.

Using multi-objective optimization to minimize GHG emissions and maximize energy efficiency of multifamily residential buildings in Ontario

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In order to make human settlements sustainable, it is fundamental for households to be mindful of their energy consumption to reduce greenhouse gas emissions (GHG) and improve energy efficiency. This process begins with data collection at the household level to determine the factors which influence GHG emissions. The government of Ontario has been involved in this process by collecting data about the energy intensity of multifamily residential buildings. Using artificial neural networks, our team predicted GHG emissions of these buildings to a ± 1.35 kgCO2e/m2 margin of error, and predicted Energy Star efficiency scores to a ± 9.60 margin of error. This was based on data about a building's electricity, natural gas, and water consumption as well as the energy needed to produce and distribute energy to a building from the "Energy and water usage of large buildings in Ontario" dataset. We also performed a multi-objective optimization with NSGA-II to determine the energy inputs that maximize efficiency and minimize GHG emissions. With this data, it will be easier for consumers to identify target values of electricity, natural gas, and water that can be consumed sustainability. Furthermore, given the clear correlations

shown by the model, we encourage governments to engage in similar data collection for low density single family household units in order to determine a sustainable method of energy consumption.

Multivariate analysis on the relationship between population demographics and the housing market

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In Canada, costs of housing have become increasingly unaffordable in recent years. The supply of housing has not been able to keep up with the demand, resulting in an affordability crisis where people of low socioeconomic status cannot compete with the wealthy for a place to live. As the cost of housing is influenced by the demand from people, it is important to understand population changes so that housing suppliers can plan to ensure there is adequate shelter for all. In this study, the relationship between population characteristics and variables in the housing market in Canada was analyzed. Data related to age distribution, immigration, and family size of different years found from the Canadian census was plotted against housing costs and types of houses in demand in major urban cities. Ordinary least squares simple linear regression and multiple linear regression were conducted on Python to understand the relationships. It is found that the number of economic immigrants have the highest impact on the rising housing costs. Furthermore, Chinese, Black, Filipino, and refugee populations suffer the greatest from housing inaccessibility. The insights gained from the analysis could support policy makers' decision making on future housing development to meet the needs of Canadian people.

Population demographics and the housing market

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The Coronavirus disease (COVID-19) is an airborne disease that has caused a worldwide pandemic resulting in over 6.5 million deaths worldwide and 47,862 in Canada alone (CNN, 2022). Air transmits viruses such as COVID-19 and affects people's health in enclosed spaces such as buildings and public transport. HVAC systems play an essential role in ensuring that the transmission of these viruses is limited. But, these systems can often be expensive and affect the economy worldwide. Having 100% fresh air through HVAC systems drastically increases protection against COVID-19. It can improve our health and lifestyle, even disregarding the COVID-19 pandemic. We are looking to enhance portable HEPA air cleaners to remove indoor pollutants, remove ultrafine particles and protect us from airborne viruses. We will be able to create a portable HVAC system that can be used in houses across the world. We will test and analyze durable but inexpensive filters. Then we will create our own filter, possibly using a 3D printer. We will create a set of guidelines for houses to follow when using the HVAC system for more efficient use and proper protection against airborne viruses. These will come in an easily accessible pamphlet/poster and will give tips such as opening windows and doors and regularly cleaning or replacing the HVAC systems. For this, we will research and test how our HVAC works most efficiently.

Urban city planning around Vancouver, Canada

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The planning of cities is a significant part of the housing area. Since we can pay for the citizen for their rents and housing, we can only improve the utilities near them to give them a more convenient environment to live. How a city is laid out significantly impacts its residents, and it must meet the demands of various groups without interfering with those of other groups. The demands of people across multiple age groups and racial and economic groupings are examined in this study. It asks how the various groups of people's needs can be satisfied simultaneously without drastically altering the city. The study will be carried out by aggregating the data from multiple groups of people and calculating an average of the collected data. On the other hand, this method will also set a cut-off line of 80 percent to evaluate if the citizen is satisfied with this part. The main objective is finding a solution allowing all city residents to be content with the city's structure.

Developing a dynamic framework for public rental housing in Toronto

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Housing inequality has been a prevalent issue affecting Toronto throughout its history. Past research shows that the city struggles to accommodate its rapidly increasing population. The shortage of fair- priced houses has caused significant financial struggles for lower-income households. Research also suggests that housing conglomerates intentionally drive poorer households out of the city, vacating homes for more affluent families. Governmental deregulation has led to increased dominance by corporate housing monopolies. Thus, the government must implement practical solutions to alleviate these issues. This study uses open data from the City of Toronto and Statistics Canada to create a ranking system for neighbourhoods in Toronto. Based on the socio-economic conditions of neighbourhoods, they are clustered using the k-means algorithm and are ranked based on the urgency of housing issues. These algorithms found Moss Park and York University Heights as neighbourhoods most needing governmental public housing. This study proposes a framework to provide affordable and adequate rental housing to the most deprived areas by considering construction and operation costs, rental prices, and proximity to public services. The target rental price will be 10- 15% of household income and require 10% governmental subsidies to cover construction and operational costs. This study documents the extreme disparity in welfare between neighbourhoods and presents an enhancement to Toronto's existing public housing system, advancing the goal of equity in life, work, and play. Given the model's plausibility in the most impoverished areas, it can be extended to public housing initiatives in other regions.

Investigating the correlation between various housing factors and life satisfaction to build a model for sustainable living

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It is known that life satisfaction is directly correlated to one's mental and physical health. There- fore, the characterization and weighting of the various components of life satisfaction are crucial first steps to maximizing its positive effects. This study aims to: (1) Identify the main factors related to housing that impact life satisfaction, (2) Derive the weightings of these factors with respect to life satisfaction, and (3) Create a formula to predict life satisfaction on the municipal level. Multiple linear regression was used on the Variation in Life Satisfaction among 1200 Canadian Neighbourhoods and Communities data set from McGill University and revealed that sense of belonging to the local community, spending on shelter, length of residence, commute time, and population density were the main factors that contributed to life satisfaction. Of these factors, belonging to the community and cost of living had the highest absolute weighting. Using this novel approach, municipalities will be able to make more informed and efficient developments in their communities to maximize their sustainability and life satisfaction.

Removing the negative connotations of subsidized housings and how it's both beneficial to the impoverished and the communities near

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Subsidized housing is implemented to help ensure that all community members have the access to affordable housing regardless of their income level. It's often funded by government programs and offers reduced rent to lower-income families who are unable to afford market-rate housing. A common belief for subsidized housing is that it causes negative consequences that can impact the surrounding community. A positive correlation between the presence of subsidized housing and increased crime rates is still a myth, which is yet to be proven. Subsidized housing can lead to the area being classified and labeled as a low-income housing area but not be correlated with crime rate. Datasets from Statistics Canada, Our World in Data, and various publicly published data on subsidized housing from Canadian provinces were gathered. A weak positive correlation between areas with subsidized housing and areas proxy to its offsets with high crime rates and lower property

values was found in the process. The widespread belief that subsidized housing development in a neighborhood leads to neighborhood decline is false. However, subsidized housing would be expected to affect neighborhoods only under certain circumstances, and the conflicting findings suggest that is the case. These results provide insight into the viability of subsidized housing in order to achieve SDG 11.

A study of the correlation between the census characteristics and housing affordability in Canada

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The United Nation's eleventh Sustainable Development Goal, "Sustainable Cities and Communities", aims to reduce disaster risk, improve living conditions, and build more infrastructure globally. In Canada, this goal has yet to be met. Rising prices have made housing unaffordable, and many still need decent living conditions. This work revealed the changing landscape of housing affordability in Canada. After constructing a comprehensive data set using the Canadian Census data from 1996 to 2021 that includes 297 census divisions, we took the following steps: First, we visualized the change in housing affordability in the past 30 years using line charts and earth maps. Secondly, we used the chi-square test to check the correlations of different census characteristics to core housing needs. Thirdly, we studied how the changing characteristics affect housing affordability using panel data regression models. We found that housing affordability is worse in urban areas than in rural ones. And housing affordability has improved in rural areas in Ontario. The fixed effect model better fits the data compared to the pooled ordinary least square and random effect model. The top three characteristic groups that correlate most to housing affordability in Canada are age, household income, and marital status. The results of this study will help inform policymakers and stakeholders about the current state of housing in Canada and provide insight into how to address housing affordability issues.

How accessible is fair housing to minority groups in Canada?

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Accessible and affordable housing has a profound impact on everyone around the world. It is crucial that everyone has access to fair housing, as it could be argued that the basis of someone's livelihood starts with housing. It is important to recognize whether housing is truly accessible and affordable to all, regardless of social status or race. The purpose of this study is to examine whether minority groups can attain this necessity of accessible and affordable housing. Datasets from Statistics Canada [1] [2] and Canada Mortgage and Housing Corpo- ration [3], specifically looking at its Housing Market Information Portal, were analyzed to find data relevant to this study. Using these sites various data was extrapolated using proportions from different population censuses. It is predicted that this study will show evidence that there is a difference between minorities and non-minorities with fair housing, this being people of a minority have significantly lower access to affordable housing. This prediction was supported by the finding of the differential between minorities and non-minorities in core housing need, as well as the more in-depth research regarding the location and severity of the shortfall. In addition, specific groups of people were analyzed to gain a greater understanding of the issue. The results lead to an understanding that housing is not truly accessible and affordable to all, regardless of race and social status. With this knowledge, one can now work towards understanding why there is this difference and the paths to take to make this change.

Research on people's lifestyles and their preference for smart home technology

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The rising prominence of smart homes in recent decades

has profoundly influenced people's lives. Our study aims to investigate the relationship between people's lifestyles and their preference for smart home technologies. Specifically, we will be focusing on how long different demographics - considering factors such as age, working status, and housing type - spend in the pub lic, private, semi-private, and kitchen areas of the house. We will also correlate between living habits and reported lifestyle outlook. We obtained the open source dataset from Dimensions website [3], which derived from a web-based experiment with 254 respondents. The experiment consisted of both a questionnaire and two main tasks to measure daily living arrangement and spatial layout arrangement; these tasks were conducted in a 3D interactive smart home by respondents. We are considering using ANOVA and the two way tests to analyze our data, concerning the matter of space use. We aim to derive a clear view of the future of the utilization of smart home technology.

Investigating the effects of the COVID-19 pandemic on urban, suburban and rural housing markets

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The COVID-19 pandemic has and continues to affect our housing markets. So, we are investigating whether the COVID-19 pandemic had any effect on the gap between rural, urban and suburban population centers. Our theory is that that the housing costs in more rural areas will have grown at a higher rate than housing prices in urban and suburban areas. To prove this we will use the Greater Toronto Region and compare its rural, suburban and urban areas growth rates from 2015-2022 using the year over year change of said methods. This means that we will compare for example the cost of houses in December of 2021 and the cost of houses in December of 2022. The data we are using to accomplish said goal is that of the Toronto Regional Real Estate Board (TRREB) MLS Home Price Index Archive.

An investigation into factors correlated with regional co-living frequencies

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Recent developments in Canadian infrastructure have renewed the interest in co- living arrangements amongst several demographics. As such, this study aims to analyse an array of socioeconomic factors and their influence on the burgeoning of co- living frequencies in Canadian cities. To accomplish this, we used two metrics, STIR and the proportion of co-living arrangements. We collected data pertinent to each metric from the 2021 Canadian Census of Population, particularly a portion of the census concerning metropolitan areas. Later we employed a chi-square goodness of fit test to determine if the variation in co-living frequencies was significant. Moreover, we performed a linear regression that compared STIR to the proportion of two or more person non-census family households. Our results showed that housing affordability and frequency of co-living in a city are loosely correlated. It can be inferred that co-living in Canada is not a response to housing affordability but rather to alternate factors.

Analyzing and Predicting Housing Affordability in New York City

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As a densely populated major city, New York City (NYC) has a long-term issue in providing fair housing. One main reason is the poor affordability caused by supply shortages and excessively rising housing prices. To help improve housing affordability in NYC, it is necessary to analyze the currently available data and seek possible solutions. For our study, we used the rolling sale data to analyze price and square foot distributions and predict their trends based on population and income changes. From the results, we gained the knowledge that with the steady increase of the required number of housing units and the rising of average sale prices, the situation of fair housing in NYC can become much more severe. Fortunately, our results also shed light on possible directions for improving this situation. Our multiple trained machine learning models help predict the housing price based on square footage, the total number of units, and other factors. The distribution that we obtained together with

the income level changes should help the government and related agencies plan future housing development to match the income and household size of the residents. Furthermore, the relatively low correlation between the unit price and size provides the information that there are possibilities of creating larger housing units with acceptable prices.