REAL ESTATE DEVELOPMENT STRATEGY IN EMERGING REGIONAL CITIES: DATA-DRIVEN FRAMEWORK FOR INFRASTRUCTURE AND SUSTAINABILITY PLANNING

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Abstract. Regional cities in ecologically sensitive areas face a fundamental tension between development pressure and environmental conservation, yet evidence-based planning frameworks tailored to their specific stakeholder realities remain scarce. This paper explores Sigulda County, Latvia, a tourist-focused municipality that is incorporated in Gauja National Park, as an example of an emerging regional city that is negotiating strains of growth in a limited ecological and regulatory environment. The study is based on a multi-method analytical model that integrates Pearson correlation analysis, K-means clustering, multiple linear regression (MLR), and machine learning validation using Random Forest (RF) and Decision Tree (DT) models because it relied on a structured questionnaire survey of 110 stakeholders (urban planners, developers, residents, policy makers, and investors). There are three compliant findings that are pre-empted. First, it can be seen that infrastructure development proves the best quantitative predictor of perceived real estate market demand ($\beta = 0.192$, $p = 0.053$): it is supported in RF (feature importance = 0.25) and DT (0.30) models. Second, K-means clustering distinguishes three groups of stakeholders that have a systematically different development agenda, necessitating differentiated policy instruments as opposed to homogenous policy responses to the planning agenda. The combination of the results justifies an integrated development strategy, which concurrently focuses on physical infrastructure investment, ecological stewardship, and multi-stakeholder engagement as mutually supporting pillars of sustainable regional real estate strategy.

Keywords: infrastructure development, real estate development, regional planning, Sigulda, urban sustainability.

Introduction

One of the more daunting areas of real estate strategic management in the modern city setup is the smaller regional cities. In comparison to metropolitan markets, where the capital flows and the institutional structures are comparatively well-established, the regional cities have to operate at the intersection of insufficient investment potential, instable environmental contexts, and multi-actor governance structures, about which the stakeholders have radically different and often conflicting visions of the desirable development outcomes [1; 2].

Sigulda is a pure commuter settlement, a cultural heritage site and a major eco-tourism spot in Latvia; it is also located about 50 km southeast of Riga and a major entrance gateway to Gauja National Park [3]. The presence of three identities creates clashing demands on land use: residential growth due to urban out-migration in Riga, commercial growth due to tourist attraction, and conservation due to EU Natura 2000 designations and national park zoning rules [4; 5]. These pressures need to be balanced using strategies, which are locally determined by the realities of local stakeholders, as opposed to ones, which were established through national or EU-level planning principles.

The literature on the Baltic and Latvian market is generally divided into two groups, namely macroeconomic drivers of the market [2; 6] and qualitative examination of policies [7], which creates a methodological gap between the stakeholder perception modelling and quantitative analysis, as well as between the stakeholder perception modelling and integrated spatial planning theory. This gap is discussed in this paper by a mixed-methods analysis of Sigulda that preFig.s three equal pillars of analysis, namely infrastructure investment, sustainability integration, and stakeholder segmentation [8].

The study aims to achieve three main goals: (1) to measure the comparative role of the main variables on the perceived demand of real estate by the stakeholders; (2) divide the stakeholder population into empirically specific groups with varying development priorities; (3) generalise the results into an integrated planning system based on Growth Pole Theory, Land Rent Theory. The value of the paper lies methodologically in its evidence about the usefulness of unsupervised machine learning and inferential statistics used together in planning the research; empirically, in the form of the first quantitative segmentation of the Sigulda market by stakeholders; and strategically, in the differentiated, actor-based development model with direct policy ramifications.

Theoretical framework

The research has three theoretical traditions that form its foundation. Its theory, Growth Pole, has interested spatialisation by Boudeville, which was first hypothesized by Perroux in the 1950s as an area in which economies develop focuses on specific centres of activity that lead to cumulative growth in the surrounding regions as they form their forward and backward relationships [9], [10]. The town of Sigulda is a regional growth pole because of the concentration of tourism and proximity to Riga; according to the theory, the diffusion capacity of the pole is limited by the quality of the infrastructure linking it to the hinterland, which is why investing in infrastructure is one of the conjunctive strategy variables.

Land Rent Theory, which has its origins in [11; 12] and is currently described using the bid-rent model by [13], is a conceptualization of spatial dispersion in property prices based on access to the central nodes [14; 15]. The theory applied to Sigulda suggests that the land near the town centre and other places of high accessibility to tourists will have higher rents and outlying rural land will be subjected to lower intensity residential and agricultural utilization, which is restructured by the enhancement of transport and communication infrastructure, directly correlating physical investments with the creation of real estate values.

The normative framework used to operationalise the above to planning policy is the Smart Growth principles, which suggest compact, transit-oriented, and mixed-use development as an alternative to low-density sprawl [16; 17]. The Smart Growth principles focus on the need to develop the urban areas in the existing built environment, retain open space, and support multi-modal mobility is directly compatible with the responsibilities of Gauja National Park zoning regime in the place of the ecologically limited environment of Sigulda. All three theories taken as a bundle form a stratified approach to analysis, Growth Pole Theory is a diagnosis of the spatial logic of investment concentration, Land Rent Theory is a description of subsequent property value gradients, and Smart Growth converts both of these into practical land-use planning tools [18].

Materials and methods

The primary data was gathered through a structured questionnaire survey based on a questionnaire that was administered to the most important stakeholders of Sigulda County within a three-week time frame through the email and institutional networks. The target population entailed those who are directly interested or directly influenced by real estate development in the county such as urban planners, real estate developers, residents, policy makers and investors. This was a multi-group composition that was purposive such that both the supply-side actors (developers, investors) and the governance- and demand-side actors (residents, planners, policy makers) were included in the sample. The last dataset consisted of 110 valid responses.

The questionnaire was made up of Likert-scale questions (1 = Very Low to 5 = Very High) on nine thematic variables, which included perceived market demand and regulatory support, economic feasibility, infrastructure development, concerns of the environment, community acceptance and preferences of residential development, commercial development, and green building development. Each of the items was based on the available research on the dynamics of the Baltic and Latvian real estate [1; 19]. One more one-item question requested the respondents to evaluate the role of the Sigulda Municipality in the development of real estate by the same 5 points scale.

The analysis was done in four consecutive steps. To describe the distributions of the responses and inter-variable correlations, first, descriptive statistics and Pearson correlation analysis was calculated between all nine variables. The test performed was a one-way ANOVA to determine whether there were statistically significant differences in variable ratings by the category of stakeholder based on occupational group membership. Second, Z-score normalisation ($Z = 0, 1$) was used to standardise all variables before the clustering in order to make cross-scales comparisons. The K-means clustering was subsequently used to cluster the respondents into internally homogenous groups with the same response profiles. Third, Ordinary Least Squares (OLS) was used to estimate MLR by using Python and the stats model package whereby the dependent variable was Perceived Market Demand, and the remaining eight survey dimensions were independent predictors. There were data on model diagnostics R^2, F, p-value of each coefficient, Durbin-Watson statistic of residual autocorrelation, Jarque-Bra statistic of residual normality.

Fourth, RF and DT models were also trained using the same preprocessed data as independent validation and cross-checking tools. The RF model which is a collection of bootstrapped decision trees where the random selection of features at a split was taken; was used to obtain feature importance scores and cross-validate the regression results; the DT model offered a more explainable, one tree appendix. All the analyses were conducted in Python in the Jupyter Notebook workspace (Anaconda distribution).

Results and discussion

The valid respondents (*n* = 110) were spread in five occupational categories as follows: urban planners (32.7%), residents (26.4%), real estate developers (22.7%), policy makers (9.1%), and investors (9.1%). Fig. 1 represents the occupational profile of the sample. Most of the respondents (32.7%) rated the role of the Sigulda Municipality in real estate development as moderate (rating 3), 27.3% rated it high (rating 4), and 12.7% rated it very high (rating 5) in response to the question. On the lower, 16.4% picked "Low" (2) and 10.9% picked "Very Low" (1). Fig. 1 represents the occupational profile of the sample.

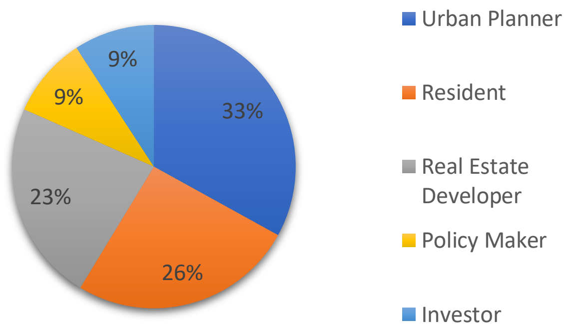

Fig. 1. **Occupational profile of survey respondents (*n* = 110)**

Table 1 shows descriptive statistics of all nine variables in the survey. Variables had a mean score of between 2.86 and 3.20 with standard deviation of about 1.45 all around, therefore, wide and roughly symmetric dispersion across the Likert scale. The highest mean (*M* = 3.20, *SD* = 1.48) was registered in Environmental Concerns and the lowest means were registered in Community Acceptance (*M* = 2.86, *SD* = 1.45) and Preference for Green Building (*M* = 2.86, *SD* = 1.40). The values of skewness were found to be near zero to ensure the presence of approximately normal distributions of all the variables. The variance was fairly constant between variables with the values of 1.96 to 2.19.

Table 1

Descriptive statistics for all nine survey variables (*n* = 110)

Variable	N	Mean	Std. Deviation	Minimum	Maximum	Variance	Skewness
Community Acceptance	110	2.855	1.445	1.0	5.0	2.089	0.222
Economic Feasibility	110	3.036	1.452	1.0	5.0	2.109	0.046
Environmental Concerns	110	3.200	1.476	1.0	5.0	2.180	-0.231
Infrastructure Development	110	3.073	1.457	1.0	5.0	2.123	-0.092
Perceived Market Demand	110	2.891	1.429	1.0	5.0	2.043	0.003
Preference for Commercial	110	3.064	1.479	1.0	5.0	2.189	-0.077
Preference for Green Building	110	2.855	1.400	1.0	5.0	1.960	0.101
Preference for Residential	110	2.936	1.429	1.0	5.0	2.042	0.095
Regulatory Support	110	2.891	1.403	1.0	5.0	1.970	-0.046

The heatmap using Pearson correlation shown in Fig. 2 indicated that the overall inter-variable correlation structure was weak and most of the coefficients were below the value of the Pearson correlation coefficient, $r = 0.30$. The analysis had the highest positive value of Economic Feasibility and Infrastructure Development ($r = 0.23$). The relationship between Regulatory Support and Infrastructure Development ($r = -0.22$) was negative. Preference for Residential Development was also negatively associated with Environmental Concerns ($r = -0.22$), and preference of Green Building ($r = -0.16$). Perceived Market Demand had very weak correlations with the majority of other variables with the highest being with Infrastructure Development ($r = 0.14$).

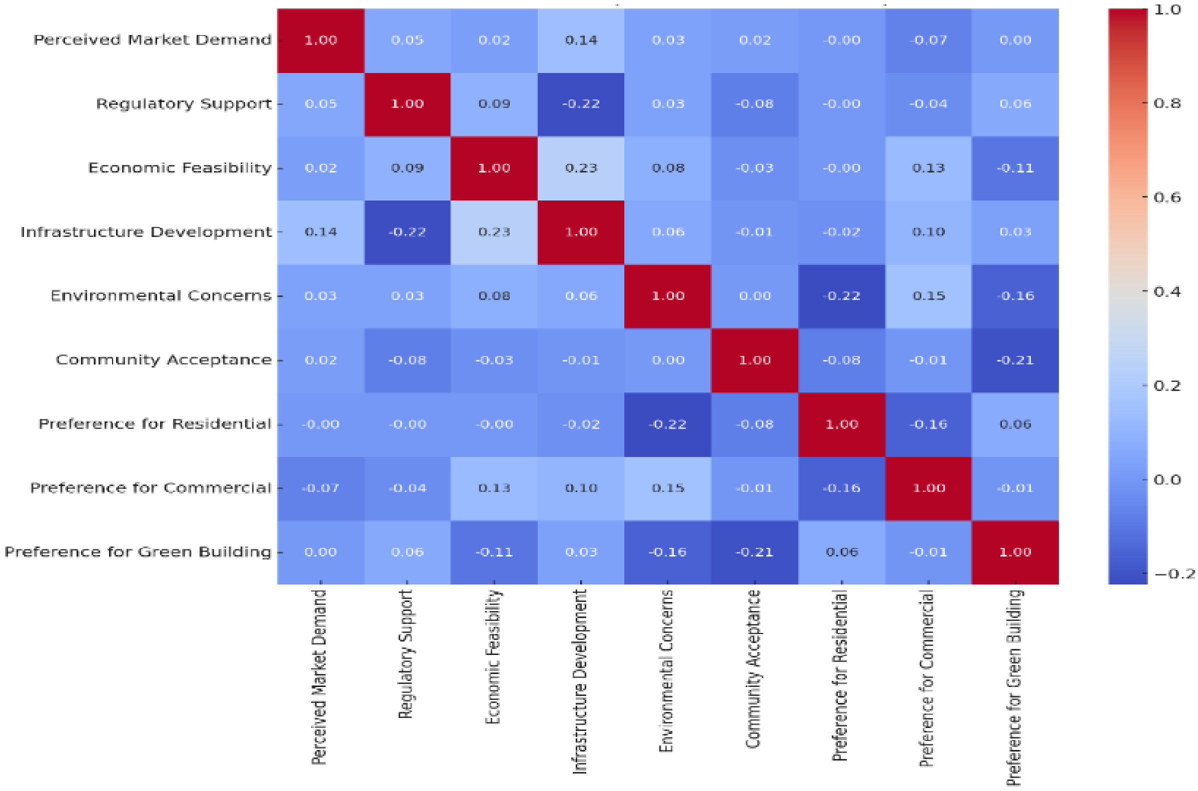

Fig. 2. **Pearson correlation heatmap for all nine real estate development survey variables**

The results of the one-way ANOVA, as in Table 2, did not give any statistically significant inter-group differences at $p < 0.05$ in any variable. The F-value was greatest in infrastructure Development ($F = 2.179$, $p = 0.076$), which is slightly small but not significant. The other variables including Community Acceptance ($F = 0.653$, $p = 0.626$), Economic Feasibility ($F = 0.886$, $p = 0.475$), Environmental Concerns ($F = 0.344$, $p = 0.848$), and Perceived Market Demand ($F = 0.553$, $p = 0.698$) yielded low F-values and high p-values, which is the same result; that there is a convergent perception across occupational groups.

Table 2

One-way ANOVA results by stakeholder occupational group

Variable	*F*-Value	*P*-Value
Community Acceptance	0.653	0.626
Economic Feasibility	0.886	0.475
Environmental Concerns	0.344	0.848
Infrastructure Development	2.179	0.076
Perceived Market Demand	0.553	0.698

K-means clustering ($K = 3$) partitioned the 110 respondents into three distinct segments. The mean scores for each variable across the three clusters are presented in Table 3.

Cluster 0 ($n = 37$) recorded the highest preference for residential development ($M = 3.92$) and a moderate inclination toward green building ($M = 3.27$), while returning the lowest environmental concern score of the three groups (*M* = 1.92). Regulatory support was rated at *M* = 3.00 and market demand at *M* = 2.78 within this cluster.

Cluster 1 (*n* = 43) was the largest segment and recorded the highest scores for commercial development preference (*M* = 4.12), environmental concerns (*M* = 3.91), economic feasibility (*M* = 3.26), and infrastructure development (*M* = 3.44). Preference for residential development was the lowest among the three clusters in this group (*M* = 2.19).

Cluster 2 (*n* = 30) was the smallest segment and recorded the highest community acceptance score by a wide margin (*M* = 4.60) as well as elevated environmental concerns (*M* = 3.67). It returned the lowest preference for green building of the three clusters (*M* = 1.77) and a moderately elevated regulatory support score (*M* = 2.83).

Table 3

Cluster mean values for all nine survey variables across Clusters 0, 1, and 2

Cluster	Market Demand	Regulatory Support	Economic Feasibility	Infrastructure Development	Environmental Concerns	Community Acceptance	Residential Pref.	Commercial Pref.	Green Building Pref.
0	2.78	3.00	2.84	2.59	1.92	2.49	3.92	2.19	3.27
1	2.98	2.60	3.26	3.44	3.91	2.28	2.19	4.12	3.12
2	3.00	2.83	3.33	2.93	3.67	4.60	2.53	2.80	1.77

Table 4 displays the results of the MLR model. The total model gave a low R^2 ($F = 0.725$, $p = 0.669$). The coefficient of Infrastructure Development ($\beta = 0.192, p = 0.053$) is the only variable that took a positive value with a traditional significance of 0.053. It was also positive in terms of Regulatory Support ($\beta = 0.135$, $p = 0.178$). The rest of the variables Economic Feasibility ($\beta = -0.033$, $p = 0.743$), Environmental Concerns ($\beta = -0.026$, $p = 0.784$), Community Acceptance ($\beta = 0.064$, $p = 0.508$), Preference for Residential ($\beta = -0.067$, $p = 0.509$). Preference for Commercial ($\beta = -0.068$, $p = 0.490$), and Preference for Green Building ($\beta = -0.003, p = 0.978$). The Durbin-Watson statistic (1.988) was not found to be significantly below 2.0, indicating the lack of a large residual autocorrelation. The 95% confidence interval on the Infrastructure Development was -0.003 to 0.386 which occupies the zero, though the bulk of the distribution is found above the zero.

Table 4

MLR coefficient summary: Perceived Market Demand as dependent variable (*n* = 110)

Variable	Coefficient	Std. Error	*t*-Statistic	*p*-Value	95% CI Lower	95% CI Upper
Constant	2.3722	0.887	2.676	0.009	0.613	4.131
Regulatory Support	0.1347	0.099	1.358	0.178	-0.062	0.332
Economic Feasibility	-0.0329	0.100	-0.329	0.743	-0.231	0.166
Infrastructure Development	0.1918	0.098	1.955	0.053	-0.003	0.386
Environmental Concerns	-0.0265	0.096	-0.275	0.784	-0.217	0.164
Community Acceptance	0.0637	0.096	0.665	0.508	-0.126	0.254
Preference for Residential	-0.0673	0.102	-0.662	0.509	-0.269	0.134
Preference for Commercial	-0.0683	0.099	-0.693	0.490	-0.264	0.127
Preference for Green Building	-0.0028	0.100	-0.028	0.978	-0.200	0.195

Table 5 provides the predictive model performance. The RF model performed better than the DT model in all three parameters: $R^2 = 0.80$ vs. 0.60, MAE = 8.33 vs. 13.44 and RMSE = 10.39 vs. 15.71. Table 6 shows the ranking of features based on the two models in terms of their importance. The Infrastructure Development was the first important factor in both DT (importance = 0.30) and RF (importance = 0.25) models. Concerns on the Environment were in the second position in DT (0.23) and the third position in RF (0.20). In RF (0.19) and DT (0.21) Population Growth was at the second and third position respectively. Regulatory Support and Economic Incentives were lower in the two models with a majority of the scores being 0.13 to 0.19.

Table 5

Predictive performance comparison: Random Forest and Decision Tree models

Model	R^2	MAE	RMSE
Random Forest	0.80	8.33	10.39
Decision Tree	0.60	13.44	15.71

Table 6

Feature importance scores for Random Forest and Decision Tree models

Feature	RF Importance	DT Importance
Infrastructure Development	0.25	0.30
Regulatory Support	0.18	0.13
Environmental Concern	0.20	0.23
Economic Incentives	0.19	0.13
Population Growth	0.19	0.21

The consistent finding of infrastructure development as the leading predictor of the perceived market demand, both in MLR ($\beta = 0.192$) as well as RF (importance = 0.25) and DT (importance = 0.30), makes it the key to any effective real estate strategy of Sigulda. Based on Growth Pole Theory, such finding is theoretically sensible: Sigulda already is a regional development pole, yet the ability of the pole to project its growth to its hinterland is limited not by the lack of demand but by the lack of infrastructure [9; 20]. The growth of transport connectivity, utility networks, and digital infrastructure further increases the scope of the effective catchment of the economic core of Sigulda and, therefore, the extension of the bid-rent gradient, as is experienced within the Land Rent Theory [14; 15]. This understanding is consistent with other evidence in Latvia that has recorded a direct correlation between the improvement of transport access and residential and tourism investment activity in regional towns [21].

A significant policy implication is the negative relationship between Regulatory Support and Infrastructure Development (r = -0.22) which signifies that policy facilitates growth and development in the infrastructure sector. Stakeholders seem to view regulatory frameworks and the quality of infrastructure as a substitution and not a complement, but that, in principle, implies that regulatory processes are perceived as a dragging process and not the facilitation of governance. This is in line with the Baltic evidence that compliance requirements and prolonged permitting procedures have reduced investor activity in the local markets [22]. The infrastructure priority would be handled by reforming regulatory systems to serve as real development enablers, by fast-tracking certifications of green-certified projects and better zoning guidance, which would also deal with the regulatory friction.

The results justify the recommendations of the EU cohesion literature on the use of infrastructure-based regional convergence policies to place smaller cities at the centre of development [23; 24]. The evidence indicates that the EU ERDF investments in the Sigulda, Riga-Sigulda transport corridor, utility systems and broadband connection in Sigulda deliver the highest multiplier impact on the confidence of the real estate market.

The three-cluster segmentation shows that the Sigulda stakeholder population cannot be considered as a homogenous constituency. Cluster 0 is conservative and incremental in its development orientation with the focus on housing supply and community-level infrastructure in Cluster 0, which is called Residential-Conventional. Cluster 1 Pro-Growth Sustainability persists in supporting commercial expansion at the same time it appreciates environmental quality and infrastructure investment as conditioning co-requisites of viable development, a posture that is much closer to integrating growth and sustainability that Smart Growth principles dictate [25]. The community acceptance and regulatory coherence lie in the heart of the priorities of Cluster 2 (Community-Regulatory), which is a governance-first orientation that is necessary to legitimise development in ecologically sensitive environments.

The multi-dimensional structure of Smart Growth offers the conceptual framework of this heterogeneity management [17]. In the case of Cluster 0, it is focused on well-serviced middle-density residential areas around the train station in Sigulda that would be affordable but would decrease car reliance. In the case of Cluster 1, this represents zoning reforms of mixed-use and zoning capital that commercializes the sustainability. In the case of Cluster 2, this will be empowering participatory planning in the sense of making sure that the voices of the communities actively influence the territorial plans in order to make Latvian legislation technically obligatory yet not necessarily practical [26].

The low level of preference of Cluster 2 to green buildings ($M = 1.77$) though the environmental pressure score was high ($M = 3.67$) indicates a serious implementation gap, which is that stakeholders are conscious of environmental pressures but do not believe that the existing mechanisms can deal with them. To fill this gap, it is necessary to have an accessible set of green finance instruments, EU Green Deal grants, green bonds, tax incentives on energy-efficient renovation, etc. – that enable sustainability to be economically viable to smaller developers and owner-occupiers, not only large commercial participants. Latvian government is already involved in an institutional vehicle of making such a transition through funding streams of the EU in areas related to cohesion and rural development [27].

There are a number of limitations that should be mentioned. The cross-sectional survey design is unable to reflect the dynamism that occurs with time; market trends, post-pandemic commuting changes, and changing EU regulatory necessities could change the relative significance of the variables that are identified here. The geographic specificity of Sigulda does not allow direct generalisation, but the analytical methodology can be applied to a similar situation of a regional city.

Conclusions

1. Infrastructure development is the strongest quantitative predictor of perceived market demand ($\beta = 0.192$; RF importance = 0.25; DT importance = 0.30). However, its full strategic value is only realized when integrated into Smart Growth spatial planning models that concentrate density around established transport nodes while safeguarding Sigulda's natural resources – the very assets underpinning its long-term competitive advantage.
2. K-means clustering reveals three distinct stakeholder segments – Residential-Conventional (Cluster 0, $n = 37$), Pro-Growth Sustainability (Cluster 1, $n = 43$), and Community-Regulatory (Cluster 2, $n = 30$) with systematically different development priorities. Uniform policy instruments will inevitably alienate at least one segment; effective governance therefore requires differentiated policy arrays and more sophisticated participatory processes than those currently available.
3. The multi-method analytical approach – combining K-means clustering, multiple linear regression ($R^2 = 0.07$), and ensemble machine learning (Random Forest ($R^2 = 0.80$), and Decision Tree ($R^2 = 0.60$)) – offers a replicable template for planners and researchers facing analogous challenges in smaller regional EU cities.

Author contributions:

Conceptualization, R.J.S.; methodology, G.K.R, N.N.P and R.J.S.; software, G.K.R; validation, A.K. N.N.R. and R.J.S.; formal analysis, G.K.R, N.N.R. and R.J.S.; investigation, G.K.R., R.J.S. and A.K.; data curation, G.K.R and R.J.S.; writing – original draft preparation, R.J.S and N.N.P.; writing – review and editing, R.J.S., A.K., and J.V.; visualization, G.R.R, R.J.S., J.V. and A.K.; project administration, A.K. and J.V.; funding acquisition, R.J.S., J.V. N.N.P. and A.K. All authors have read and agreed to the published version of the manuscript.

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