RESEARCHARTICLE OPENACCESS

# Assessment of the Impact of Industrialization to the Environmental Aspect of Barangay San Isidro, San Simon, Pampanga Using Triangulation Method

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## Abstract:

Industrialization, the shift from agriculture to manufacturing, brings economic growth, job opportunities, and technological advancements but also poses environmental and health challenges. This study evaluates industrialization's environmental impact in Barangay San Isidro, San Simon, Pampanga, using a triangulationmethod that combines quantitative and qualitative approaches. Itassesses community perceptionsandfactorypracticestounderstandindustrialization'senvironmentalconsequences.Theanalysis focused on industrial growth, waste disposal, and pollution (air, water, soil). Findings show significant industrialexpansion,contributingtoeconomicgrowthbutalsoenvironmentaldegradationandhealthrisks.

Surveys and interviews reveal residents recognize both job creation benefits and pollution-related drawbacks, such as reduced access to clean air and water. The study emphasizes the need for balanced industrial growth and environmental conservationfor sustainable development. Recommendations include enhancedtransparencyinwastemanagement,continuouspollutionmonitoring,collaborativeenvironmental management efforts, and policy evaluation for sustainable industrial development. Future research should expand to neighboring areas, conduct comparative analyses, evaluate existing policies, and explore innovativetechnologiestomitigateenvironmentalimpacts. Byaddressingthesechallengescollaboratively, stakeholders can promote sustainable industrial growth while protecting the local community and environment in Barangay San Isidro.

*Keywords:***Industrial Growth, Physical Environmental Impact,Triangulation Method,Sustainability**

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## I. INTRODUCTION

We are currently in the Fourth Industrial Revolution (4IR), or Industry 4.0, emphasizing the integration of digital technologies into industrial processes [1]. Industrialization marks a transition from rural or resource-dependent economies to mechanizedmanufacturing,drivenbygovernmental policies, labour-saving innovations, entrepreneurial activities, and increasing demand for goods and services [2]. While it brings economic progress, increasedpopulation,andurbanization,italsostrains essential systems and brings environmental impacts close to their tolerance limits [3]. Balancing industrialization and environmental sustainability are a significant challenge. Effective policies and local mitigation measures are crucial to minimizing industrialization's negative environmental impacts [4]. Industrialization leads to substantial pollution, including air pollution from fossil fuel combustion and water pollution from factory emissions. Soil contamination from heavy metals and toxic chemicals further exacerbates environmental degradation [5][6].

The Philippines, one of Asia's fastest-growing economies, faces severe environmental challenges. Ineffective management has significantly degraded its biodiversity resources, making the country highly vulnerable to environmentaldisasters[7].TheMunicipalityofSan Simon, Pampanga, transitionedfrom an agricultural town to an industrial hub, attracting investment but facing regulatory compliance challenges. By 2020, three operational warehouses lacked the necessary business permits [10]. The steel industry in San Simonhasnotablycontributedtosubstantialdailyair pollution,affectingatleastsixbarangaysandposing health risksto the local population[11]. Despite the economic benefits brought by industrialization in San Simon, its environmental and health impacts require scrutiny. Addressing nationwide environmentaldegradationispartoftheSustainable Development Goals (SDGs), targeting Clean Water andSanitation,SustainableCitiesandCommunities, andResponsibleConsumptionandProduction[12].

This study aims to assess the impact of industrialization on Barangay San Isidro, focusing on environmental factors. It evaluates residents' perspectives on industrial expansion and analyses industrial practices affecting the community. The goalistoidentifyimprovementstomitigatenegative environmental impacts and develop sustainable strategies that promote industrial growth while ensuring community well-being.

### *A. BackgroundoftheStudy*

Industrialization, characterized by technological and organizational changes, has transformed production and labour, enhancing productivity, living standards, population growth, urbanization, cultural shifts, and global power dynamics [13]. However,ithasalsoledtosignificantenvironmental issues, such as air and water pollution and urban sanitationproblems,negativelyimpactinghealthdue to the release of pollutants [5]. Crowded cities face unsanitary conditions, worsened by emissions from coal-powered factories. The Industrial Revolution marked a rapid increase in atmospheric carbon dioxide.

San Simon, Pampanga, once primarily agricultural, has seen substantial industrialization, particularly in Barangay San Isidro [14]. This shift has boosted the economy and created jobs but has also led to environmental harm, including air and water pollution [15]. Factory emissions contribute significantly to global climate change and environmental degradation due to raw material extraction and improper waste disposal.

Inresponsetopollutionconcerns,theDepartment of Environment and Natural Resources - Environmental Management Bureau conducted air and water sampling in San Simon [16]. Local leader Randie Flores highlighted the impact of pollutants from steel mills, which have led to respiratory illnesses in at least six communities. He identified majorsourcesofairpollutioninBarangaySanIsidro, where residents have been vocal about their complaints regarding certain industries operating without permit [11].

### B. StudyArea

ThestudywasconductedinBarangaySanIsidro, San Simon, Pampanga, athird-class municipality in the province of Pampanga, Philippines. The main sectors driving San Simon's economy include steel manufacturing, agriculture, fisheries, and poultry andswinefarming.Thezoningordinancedesignated QuezonRoadasanIndustrialandCommercialZone, butrestricteditolightandmedium-sizedindustries that adhere to environmentally friendly practices [17].

Fig.1MapofBarangaySanIsidro,SanSimonPampanga(GoogleMaps)

San Isidro is one of the 14 barangays in San Simon.Thisbarangayfallswithinanindustrialzone hosting 168 industries, with 42 dedicated to manufacturers,55toservices,and71merchandising industries.

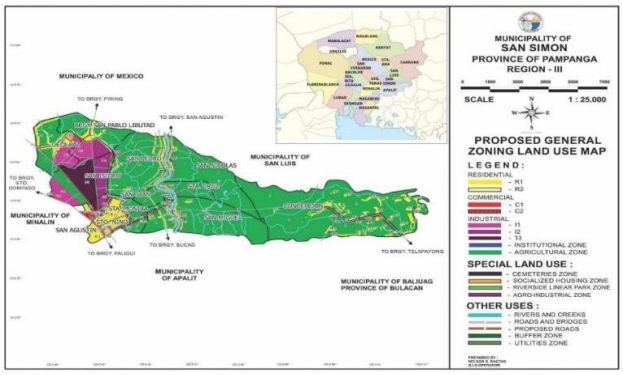



Fig.2ZoningMapof SanSimon,Pampanga

### C. Statementoftheproblem

BarangaySanIsidroinSanSimon,Pampanga,is the municipality's most industrialized area, significantlyboostingeconomicdevelopmentand job creation. However, industrialization has raised residents' concerns about environmental impacts, includingair,water,andsoilpollution,andimproper waste management, posing health risks. Reports of industrial facilities operating without necessary permits exacerbate these concerns. This prompted researchers to assess the environmental impacts of industrial growth in San Isidro. The study aimed to understand the practices affecting the environment and community, identifying specific challenges and promoting sustainable practices to mitigate environmental degradation.

### D. ResearchObjectives

Thisstudyevaluatesindustrialization'simpacton Barangay San Isidro, San Simon, Pampanga, focusingonenvironmentalfactorsandresidentwell-being, andaimstoidentify strategiesforsustainable development.

1. Evaluate the environmental impact of industrialization from the residents' perspective
2. Assess industrial growth and practices affecting the environment and community
3. Identify gaps in mitigation and provide policy recommendations for sustainable development based on findings.

### E. Scope and Limitations

This study aimed to understand the impact of industrialization on the environment in Barangay San Isidro, San Simon, Pampanga, identify knowledge gaps, and make recommendations for addressing industrialization challenges. Despite its goals, the study had limitations, relying on existing data and tools, which affected accuracy due to potentialbiasesanddatagaps[18].Itfocusedonone barangay, surveying public officials, residents, and small business owners through face-to-face surveys andinterviews.Additionally,industrypracticeswere assessed via purposive sampling. A key limitation was the inability to gather comprehensive environmentalpoliciesfromtheMunicipalitydueto private company operations outside LGU oversight.

### F. ConceptualFramework

The conceptual framework outlines the study's input,process,andoutputmethodologies.Theinputs include residents of Barangay San Isidro, manufacturing facilities, and environmental regulationsandguidelines.Participants,aged18and above, were selected using random and purposive sampling. Researchers distributed validated survey questionnaires and conducted face-to-face interviews for data collection. Statistical analysis was then used to interpret the data with graphs and tables. Theoutputidentifiedtheimpact ofindustrial practices on the environment and community, highlighted gaps in mitigation measures, and proposed recommendations for policy changes and future research.

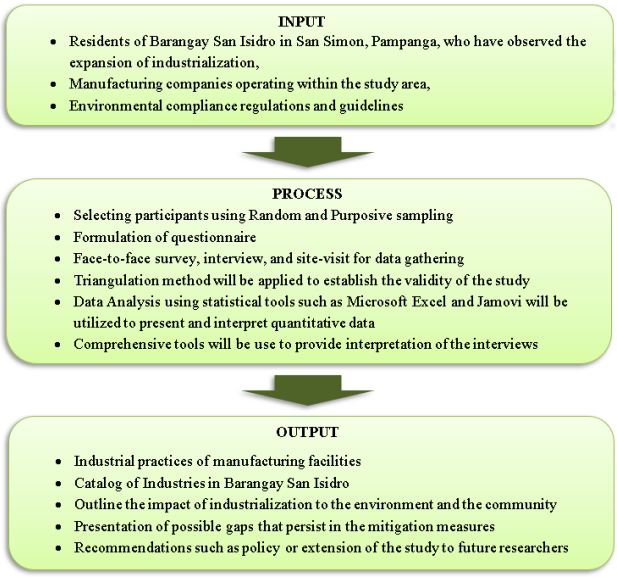



Fig.3ConceptualFramework

## II. METHODOLOGY

The diagram above depicts the methodological framework,showcasingtheprogressionofthestudy from beginning to conclusion. Each phase encompasses several specific stages, which will be detailedandfurther exploredin subsequent sections of this chapter.

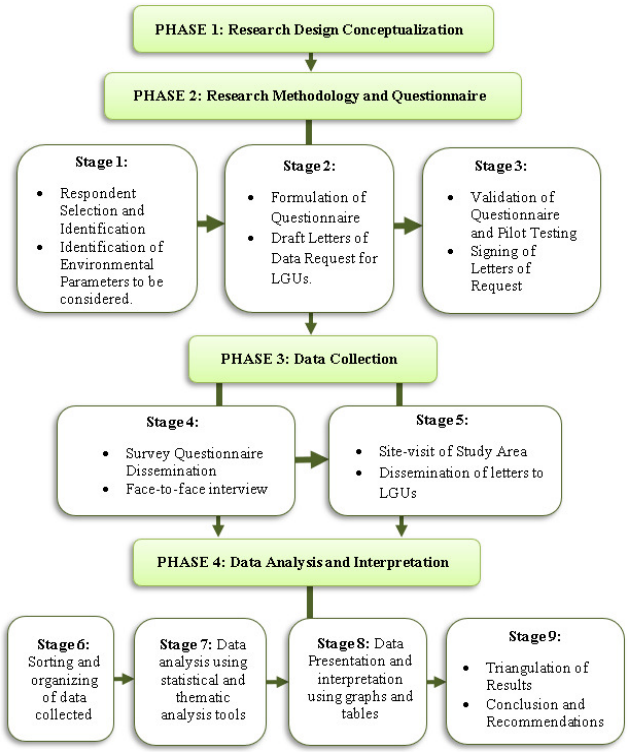



Fig.4Methodological Framework

### A. ResearchDesign

This study used a sequential explanatory mixed method [19], starting with quantitative data collection and analysis, followed by qualitative phase. The quantitative phase involved surveys in Barangay San Isidro, San Simon, Pampanga, to assess residents' views on industrialization. The qualitative phase included in-depth interviews to understand industrial compliance. This combined approach provided a comprehensive understanding of industrialization's environmental impact. The sequential design enhanced the study's validity by integratingquantitativeandqualitativefindingsfora nuanced analysis.

#### (1)TriangulationMethod

Triangulation combining quantitative and qualitative methods bolstered research credibility, considering diverse perspectives and multiple data sources. It countered biases, ensuring a comprehensive and valid analysis.

### B. ResearchLocaleandRespondentSelection

The study selected Barangay San Isidro, San Simon, Pampanga, known for its industrial prominenceandextensiveindustriallandallocation, makingitanidealsitetoexamineindustrialization's effects on the environment and community welfare.

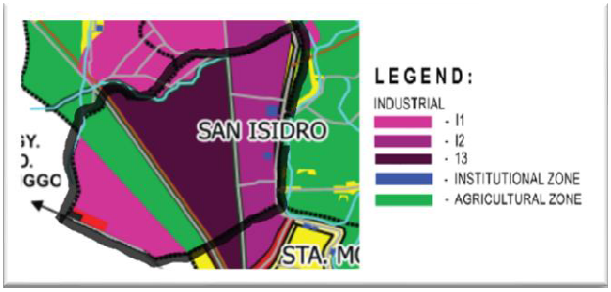



Fig.4ZoningLandUseMapofSan Isidro

Random and purposive sampling were utilized to select respondents for the community survey. The sample size of 330 was determined using Raosoft® software, considering a population of 2,330 individuals aged 18 and above in Barangay San Isidro. Purposive sampling with complete enumerationwillbeusedforthesurveytargeting42 manufacturing facilities in San Isidro, representing light, medium, and heavy industries, as per local government data.

### C. ResearchInstrument

TABLEIOUTLINE OFSURVEYS

| Surveys | Objectives | Coverage | Method |
|---|---|---|---|
| Community Impact Survey | - To assess the impact of industrialization on the environmentand community satisfaction | sample size of 330residentsof the study area | Face to face interview surveyvia homevisit |
| Facility Impact Assessment Survey | -Toevaluatethe environmental practices and impacts of specificfacilities | samplesizeof5 facilities to represent the manufacturing industriesinthe study area | Face to facesurvey interview via site visit |

#### (1) CommunityImpactSurvey

The "Community Impact Survey" assesses the effects of programs on local communities by capturing community sentiments and perceptions [20]. To evaluate industrialization's impact on the environment and community satisfaction, a "Community Industrialization Impact Survey" was used, designed based on literature review variables and adapted from previous studies [21]. Modifications were made to gather feedback on industrialization's effects on air and water quality, soil pollution, and community satisfaction with industrial activities.

#### (2) FacilityImpactSurvey

The "Facility Assessment Survey Interview" targets facility staff to assess their environmental practices and impacts. It evaluates operations, compliance, waste management, and environmental risks.Suchdataaidsinimplementingenvironmental strategiesandmitigatingimpacts.TheDepartmentof EnvironmentandNaturalResourcesusesPEMAPS, covering waste generation and land use, guiding questionnaire formulation. Secondary data from LGUs supplements information gathering. [22]

### D. DataCollection

Data gathering involves acquiring and analysing information essential to the study's research questions. Thisincludessecuring zoning mapsfrom the Municipal Planning and Development Office, environmental test results from DENR-EMB, and industry-related regulations from the Municipal Environment and Natural Resources Office (MENRO). Demographic data is obtained from the Barangay Affairs or Population Office, and a list of registered industries from the Business Process and Licensing Division. Interviews with industry representatives and MENRO provide insights and recommendations for data collection.

#### (1)DetailedSurveyMethod

The study involved quantitative surveys with residents to understand industrialization's impact on theenvironmentandinteractionswith

manufacturing staff to gather relevant information. Researchers conducted face-to-face interactions, distributing validated questionnairesafter providing a study briefing. Confidentiality was ensured under Republic Act No. 10173. Structured interviews, following a predetermined set of questions, were conducted with residents and manufacturing industries using a method triangulation approach [23].

### *E. DataAnalysis*

In this study, data triangulation was used to validate findings regarding industrialization's environmental impact [24]. Triangulatingdata from manufacturing surveys with LGU data enhances validity. Method triangulation, integrating qualitativeandquantitativemethods,enhancesresult accuracy [25]. Data were organized in Excel, then analysedtoidentifypatternsandtrends.Thismethod facilitated a comprehensive understanding of data distributionacrosscategories,strengtheninganalysis [24].

#### *(1) SurveyResultAnalysisUsingJamovi*

Data collected in Excel was analysed using Jamovi, a free statistical platform [26]. Jamovi, designed for academic settings, offers user-friendly accesstoadvancedstatisticalmethods,consolidating analytics into a single platform [27]. Descriptive statistics summarized data, including frequency distributions. Inferential statistics, like correlation tests, interpreted relationships between variables. Measures of central tendency, such as the mean, wereconsidered.Jamovifacilitatedpilottestingand questionnaire reliability checks efficiently.

TABLE II
INTERPRETATIONOFWEIGHTEDMEANRATINGIN JAMOVI

| **WeightedMean Scores** | **VerbalInterpretation** | | |
|---|---|---|---|
| 4.20–5.00 | Strongly Agree | Poor | Very High |
| 3.40–4.19 | Agree | Not Satisfactory | High |
| 2.60–3.39 | Neutral | Satisfactory | Medium |
| 1.8 –2.59 | Disagree | Very Satisfactory | Low |
| 1.00–1.79 | Strongly Disagree | Excellent | Very Low |

#### *(2) InterviewResultAnalysisUsingNVivo*

NVivo, a versatile tool, specializes in qualitative and mixed-methods research analysis, handling unstructured data like text, audio, and video [28]. Thematic analysis, known for its accessibility and flexibility, is crucial for qualitative researchers, providing foundational skills [29]. Understanding thematic analysis enhances researchers' ability to engage with other qualitative approaches [30]. NVivo benefits graduate students, improving researchefficiencyandcollaboration,andenhancing the quality of qualitative research [31].

## III. RESULTSANDDISCUSSION

### *A. LocalResidentsSurvey Results*

TABLE III
MEANANDSTANDARDDEVIATIONOFEACH VARIABLES

| **A.Industrial GrowthofSanIsidro** | | | | | |
|---|---|---|---|---|---|
| | **IG1** | **IG2** | **IG3** | **IG4** | **Ave-IG** |
| N | 330 | 330 | 330 | 330 | 330 |
| Mean | 4.04 | 4.07 | 4.05 | 4.05 | 4.05 |
| Standard deviation | 0.694 | 0.764 | 0.756 | 0.756 | 0.756 |
| **B.WasteDisposal** | | | | | |
| | **WD1** | **WD2** | **WD3** | **WD4** | **Ave-WD** |
| N | 330 | 330 | 330 | 330 | 330 |
| Mean | 3.31 | 3.31 | 3.31 | 3.31 | 3.31 |
| Standard deviation | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **C.Air Pollution** | | | | | |

| | AP1 | AP2 | AP3 | AP4 | Ave-AP |
|---|---|---|---|---|---|
| N | 330 | 330 | 330 | 330 | 330 |
| Mean | 3.92 | 3.92 | 3.92 | 3.92 | 3.92 |
| Standard deviation | 0.767 | 0.767 | 0.767 | 0.767 | 0.767 |
| **D.Water Pollution** | | | | | |
| | **WP1** | **WP2** | **WP3** | **WP4** | **Ave-WP** |
| N | 330 | 330 | 330 | 330 | 330 |
| Mean | 3.15 | 3.15 | 3.15 | 3.15 | 3.15 |
| Standard deviation | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| **E.SoilPollution** | | | | | |
| | **SP1** | **SP2** | **SP3** | **SP4** | **Ave-SP** |
| N | 330 | 330 | 330 | 330 | 330 |
| Mean | 3.51 | 3.51 | 3.51 | 3.51 | 3.51 |
| Standard deviation | 0.851 | 0.851 | 0.851 | 0.851 | 0.851 |

Perceived industrialgrowthamong330residents scored an average of 4.05, indicating agreement, with a standard deviation of 0.541. However, the perceivedsatisfactorylevelofwastedisposalscored 3.43, considered unsatisfactory, with a standard deviation of 0.794. Additionally, perceived air pollution scored 3.92, rated high, with a standard deviationof0.612.Likewise,waterpollutionscored 3.50, also high, with a standard deviation of 0.637, whilesoilpollutionscored3.47,similarlyhigh,with a standard deviation of 0.665.

### *(1) CorrelationTest*

A Spearman's rho correlation test was employed to examine the association between dependent variables (Industrial Growth and Waste Disposal) and independent variables (Air, Water, and Soil Pollution). The findings indicate a stronger correlationbetweenindustrialgrowthandchangesin air quality compared to water or soil pollution. Conversely, variations in waste disposal practices show a stronger correlation with soil pollution, followedbywaterpollution,andtheleastassociation withairpollution,asperceivedbythelocalresidents.

### *(2) Supplementaryquestions*

Asetofmultiple-choicequestionswasincludedin the survey, the results are represented as follows:

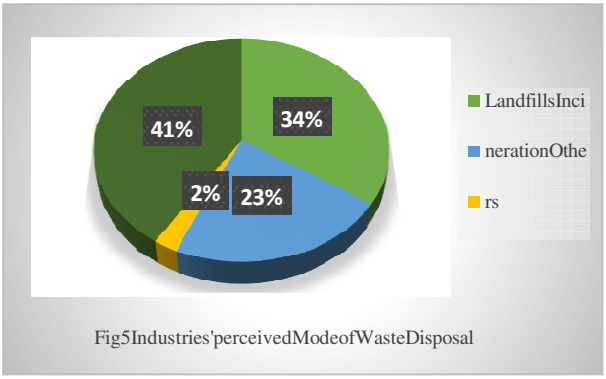



Fig5Industries'perceivedModeofWasteDisposal

### *B. LocalResidentsInterviewResults*

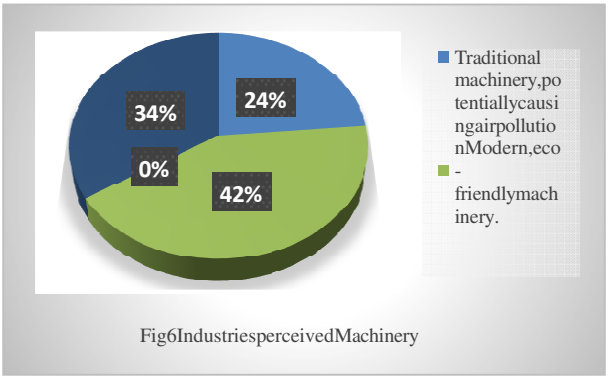



Fig6IndustriesperceivedMachinery

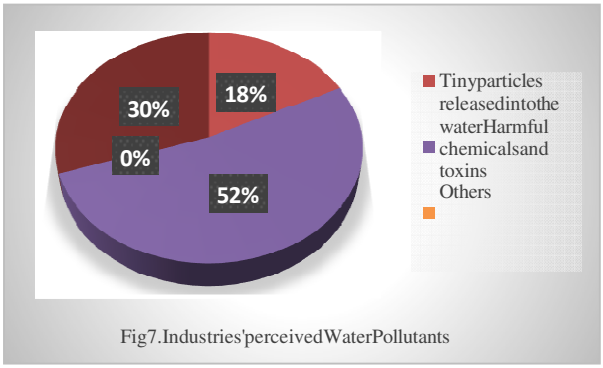



Fig7.Industries'perceivedWaterPollutants

Involving 330 participants, face-to-face interviews were conducted to explore community experiences regarding industrial growth and pollution in their barangay. Thematic analysis, a systematic method for organizing qualitative data, was employed using NVivo 14. Steps included data familiarization, initial coding, theme generation, review, theme naming, and report production. Essential information was extracted from interview transcripts,codesweregeneratedusingNVivo14,

andinitialthemeswereorganized[25].Themeswere refined to answer research questions, named for coherence,andpresentedinacomprehensivereport, as shown in the table below.

TABLEIVFIN ALTHEMES

| Theme/Code | Participants | References |
|---|---|---|
| AirPollution | 330 | 372 |
| CopingMechanismofResidents dealing with Industrial Development | 330 | 353 |
| ExperienceofPeopleinthemidst of industrialization development | 330 | 686 |
| PollutionhappenedinSanIsidro | 330 | 330 |
| SoilPollution | 330 | 333 |
| Waste Disposal | 330 | 669 |
| WaterPollution | 330 | 340 |

Interviewees perceived industrialization positively, noting job opportunities, economic growth, and technological advancement. However, they also reported negative impacts like health problems, environmental degradation, flooding, noise pollution, and poor air quality. Pollution coincided with industrial growth, indicating it as a major factor. Participants adopted coping mechanisms like resilience, optimism, and wearing facemasks. Both industry and LGU waste management practices were found lacking, indicating insufficient regulations. Air pollution primarilycamefromfactoryemissions,withvehicle emissions also contributing. Water pollution stemmed mainly from factory discharge, with other factors also involved. Soil quality was similarly affected by industrial waste and discharge.

### *C. TriangulationofSurveyandInterviewResults*

#### *(1) IndustrialGrowth*

Triangulatingdatafromsurveysandinterviewson San Isidro's industrial growth reveals widespread recognition of expansion (mean score: 4.05) and associated trade-offs. Surveys highlight healthrisks andenvironmentaldegradation,whileinterviews note job creation and economic growth but also expressconcernsaboutpollutionandlossofcleanair. This underscores the need for sustainable development practices that balance economic advancement with environmental and public health priorities.

#### *(2) WasteDisposal*

Triangulating data from surveys and interviews on San Isidro's waste disposal practices reveals a complex picture. The survey shows varied perceptions, with an average score of 3.43, and landfills as the primary disposal method. Many respondents are uncertain about industry practices. Interviews highlight concerns about inadequate regulation and monitoring, though some residents are satisfied with current practices. Thisunderscorestheneedforbetterregulatoryoversigh t, transparency, and community engagement in waste management.

#### *(3) AirPollution*

Triangulating data from surveys and interviews highlights significant air pollution concerns in San Isidro. The survey indicates high pollution levels from industries, with a mean score of 3.92. Respondents report mixed views on machinery use, withsomeconcernsabouttraditionalequipmentand othersnotingmodern,eco-friendlytools.Interviews pinpoint factory emissions and vehicle exhaust as major pollution sources, stressing the need for comprehensive measures to address both industrial and vehicular emissions for better public healthand environmental quality.

#### *(4) WaterandSoil Pollution*

Triangulating data from surveys and interviews reveals complex dynamics of water and soil pollution in San Isidro. Survey results show significant concerns about industrial chemicals and toxinspollutingwater,withsimilarconcernsforsoil pollution. The variability in perceptions highlights diverseresidentviews.Interviewsconfirmindustrial activities as primary pollution sources but also note agricultural runoff and improper waste disposal. Industrialdischargenotablydegradessoil,

emphasizingtheneedtoaddressvariouspollution sources for effective mitigation.

*(5) RelationshipBetweenVariables*

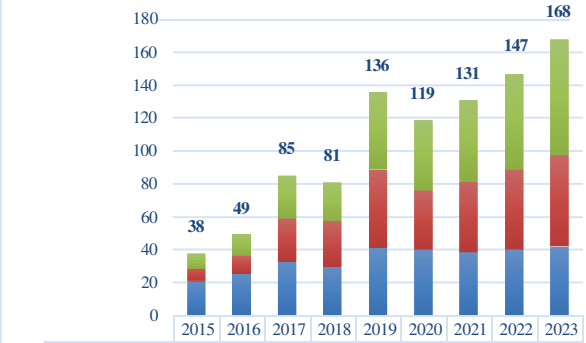
Data triangulation from surveys and interviews reveals key insights into industrial growth, waste disposal, and pollution in San Isidro. Quantitative analysisshowsnosignificantlinkbetweenindustrial growth and water or soil pollution, but significant correlationsbetweenwastedisposalandbothairand soil pollution, and a low positive correlation with water pollution. Qualitative interviews highlight residents' mixed experiences with industrialization, emphasizing increased pollution levels. These findings underscore the critical impact of waste disposal practices on environmental quality and the importance of sustainable management strategies.

### *D. IndustrialGrowthinSanIsidro*

Over the years, numerous industries have establishedthemselvesinthearea,contributingtoits economic expansion and transforming San Isidro into an industrialized area.

According to the Business Permit and Licensing Division of San Simon, Pampanga, there were38registeredindustriesintheareain2015,and by 2023, the number of industries in San Isidro had risen to 168

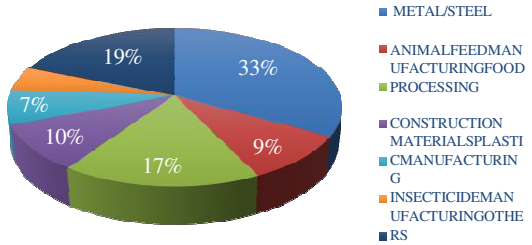
**Fig8**NumberofIndustriesinSanIsidro,SanSimon,Pampangafrom 2015 - 2023




| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| Merchandising | 9 | 13 | 26 | 24 | 47 | 43 | 49 | 58 | 71 |
| Services | 8 | 11 | 26 | 27 | 48 | 36 | 44 | 49 | 55 |
| Manufacturers | 21 | 25 | 33 | 30 | 41 | 40 | 38 | 40 | 42 |
| Total | 38 | 49 | 85 | 81 | 136 | 119 | 131 | 147 | 168 |

Thegrowingnumberofmanufacturers,some hazardousorpollutive,couldimpactthelocal environment.Asof2023,thereare42manufacturers: 14 in metal/steel production, 4 in animal feed, 7 in foodprocessing,4inconstructionmaterials,3in plastics, 2 in insecticides, and 8 invarious manufacturing sectors.

**Fig9**ManufacturersinSanIsidro,SanSimon,Pampanga 2023




### *E. ManufacturingIndustriesSurveyResults*

TABLEVCODES ANDTHEMES

| **A.Waste Disposal** | | |
|---|---|---|
| **Code/Theme** | **Participants** | **Reference** |
| AdherencetoEnvironmental Regulations | 5 | 5 |
| ProperWasteDisposal | 5 | 5 |
| WasteClassification | 5 | 18 |
| RecyclingandSortingof Materials | 5 | 5 |
| UtilizationofBarangay MRF | 5 | 5 |
| IndustrialWasteDisposal Practice | 5 | 8 |
| **B.AirQuality** | | |
| IndustriesObjective | 5 | 8 |
| ProductsProduced/Processed | 5 | 5 |
| OperationsEmission | 5 | 6 |
| AirPollutionControl | 5 | 5 |
| OperationChallenges | 5 | 6 |
| **A.WaterandSoilQuality** | | |
| WaterSource | 5 | 7 |
| WasteWater Disposal | 5 | 8 |
| Handling Deposits | 5 | 7 |
| WaterPollution Control | 5 | 5 |
| DischargingofWastewater | 5 | 5 |
| ImpactonAgriculturalLand | 5 | 5 |
| ImpacttoSurfaceWater | 5 | 5 |

Allparticipantsconfirmedtheyhaveupdated environmental clearances and practice waste

segregation. Only participant 3 generates air waste, while participants 2, 3, and 5 produce wastewater, and participant 4 generates hazardous liquid waste. Allgeneratesolidwaste.Participants1,3,and4have operational Materials Recovery Facilities (MRFs), whereas participants 2 and 5 do not. Waste disposal varies, with some hiring accredited companies and others using landfills. Most participants are in the food industry, while others focus on plastics and steel, with some engaging in recycling. Daily maintenance prevents malfunctions, and water sources are primarily deep wells, with wastewater ultimately discharged into drainage systems. Only participant5isnearwaterbodies,butwithoutimpact. No participants reported nearby agricultural land or effects on surface water.

### *F. AdditionalData*

#### *(1) WasteDisposal*

Industrial wastewater discharge in San Isidro, with 42 manufacturing industries, poses environmental risks. Only 15 industries have discharge permits, covering Highly Pollutive/Hazardous,Pollutive/Hazardous,andNon-Pollutive/Non-Hazardous categories. Notably, steel/aluminumandfoodprocessingsectorsgenerate significantwastewatervolumes,withcompanieslike Realsteel and D'Meter Fields producing 2 to 66.2 cubic meters daily, highlighting the need for effective wastewater management and treatment.

#### *(2) Air Quality*

TheairpollutiondatafromNovember11to December 29, 2023, isthe first since2017, when the monitoring device was non-functional. The DENR-EMBcouldn'trecoverearlierdata.Monitoring resumedafterthedevicewasrestored.TheSan IsidrostationshowedfluctuatingTSPlevels,with November'sreadingsbelowtheguidelinevalue(GV) of230 µg/NCM.December sawspikes,exceeding theGVontwodays,reaching280.97and255.08 µg/NCM.

| San Simon TSP Data | | | |
|---|---|---|---|
| Date Of Sampling | Results(µg/NCM) | Limits | Remarks |
| Nov 11, 2023 | 119.04 | 230 | Below GV |
| Nov 17, 2023 | 122.8 | 230 | Below GV |
| Nov 23, 2023 | 155.33 | 230 | Below GV |
| Nov 29, 2023 | 63.66 | 230 | Below GV |
| Dec 05, 2023 | 280.97 | 230 | Above GV |
| Dec 11, 2023 | 129.63 | 230 | Below GV |
| Dec 17, 2023 | 107.42 | 230 | Below GV |
| Dec 23, 2023 | 112.7 | 230 | Below GV |
| Dec 29, 2023 | 255.08 | 230 | Above GV |

Fig9TotalSuspendedParticulate Data

#### *(3) WaterQuality*

TheresearchercontactedLGUsforsurfacewater quality data in San Isidro, but none was provided. The figure shows inactive water bodies, overgrown with lilies, withnosigns offishingorirrigationuse, indicating neglect and lack of maintenance.

#### *(4) SoilQuality*

The Comprehensive Land Use Plan (2014-2024) identifies San Fernando Clay Loam in San Isidro as goodforagriculture.TheDepartmentofAgriculture in SanSimoncouldnotprovide updatedsoilquality data. Currently, no land in San Isidro is used for agriculture, and LGUs no longer assess soil quality, revealingagapbetweentheplanandcurrentzoning.

### *G. TriangulationofInterview,DatafromLGUs,andSiteVisit*

#### *(1) IndustrialGrowth*

San Isidro, San Simon, Pampanga, has shifted from agriculture to industrial use per the 2014-2024 Comprehensive Land Use Plan. The area now includesLight,Medium,andHeavyIndustrialzones. From 2015 to 2023, the number of registered industries increased from 38 to 168, with manufacturing nearly doubling to 42.

*(2) WasteDisposal*

Survey interviews and LGU site visits reveal insights into waste disposal in San Isidro. Manufacturing industries show commitment to environmental compliance, using waste segregation and having environmental clearances. While all generate solid waste, some produce liquid and air waste, including hazardous liquids. Many use accredited companies for disposal or landfills. Disparities in discharge permits among pollutive industries highlight the need for stricter regulation and monitoring to prevent environmental contamination.

*(3) AirPollution*

Survey interviews and DENR-EMB air quality monitoringofferinsightsintoairpollutioncontrolin San Isidro. Manufacturing industries vary in pollutionmitigation,withsomerecyclingandothers using air control systems like filter bags to reduce smoke emissions. Air quality monitoring shows fluctuating TSP levels, with good air quality in November but exceeding guidelines in December, highlighting the need for ongoing monitoring and proactive pollution control.

*(4) Waterand SoilPollution*

Data from industrial operations and site visits illuminate waste disposal practices in San Isidro. Industries use deep well water and vary in wastewater disposal, with some using pollution control systems and treatments before discharge. Only one participant produces sludge, collected by anaccreditedcompany.Despiteclaimsofnoimpact on farmland or surface water, site visits show neglected water bodies and unclear soil quality, underscoring the need for better monitoring and sustainable practices.

## IV. CONCLUSIONS

In San Isidro, the shift from agriculture to industry has spurred significant economic growth, with a notable rise in registered businesses from 2015to2023.Whilethistransformationhasboosted localemploymentandeconomicactivity,concerns persist over environmental degradation and public health risks associated with industries like metal production and food processing. Community feedback reveals a mix of support for industrial growth, recognizing job creation benefits, yet expressing apprehension about pollution and health impacts. Waste disposal practices, highlighted throughsurveysandinterviews,underscoretheneed forenhancedregulationandtransparency.Industries generallypartnerwithaccreditedwastemanagement firms and utilize material recovery facilities, but gaps in clarity and awareness among residents highlighttheneedforimprovedcommunicationand collaboration. Air pollution concerns are evident, with local community members and interviews pointing to emissions from traditional machinery as major issues. Someindustrieshaveimplementedair pollution control measures, though challenges like power interruptions remain. Air quality monitoring data from DENR-EMB shows fluctuations, emphasizing the necessity for continuous surveillance and proactive pollution control. Regarding water and soil pollution, survey and interview data indicate significant worries among residents, with industries identified as major contributors.Whilesomefirmsusepollutioncontrol systems,broaderconcernsabouttheimpactonwater and soil quality persist, underscoring the need for comprehensive pollution control measures and land use planning. The analysis of relationships between industrial growth, waste disposal, and pollution highlights the interconnected nature of these issues. Effective waste management emerges as crucial in mitigating pollution, suggesting a need for nuanced environmental management strategies that balance industrial growth with sustainable practices to protect public health and the environment in San Isidro.Thiscallsforacollaborativeapproachamong policymakers, industries, and communities to foster sustainable development while safeguarding environmental quality.

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