



**PLANNING MALAYSIA:**

*Journal of the Malaysian Institute of Planners*

**VOLUME 23 ISSUE 4 (2025), Page 793 – 808**

## **ASSESSING PADDY GRANARIES DEGRADATION: INTEGRATING SPATIAL ANALYSIS WITH FIELD VERIFICATION**

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### **Abstract**

This study aims to explore the extent of granaries degradation to assess the development pressures from surrounding area, primarily from the Greater Kota Bharu area while also take account of existing land development control mechanism. The scope is granaries under the Kemubu Agriculture Development Authority (KADA). Employing a comprehensive methodology that incorporates spatial analysis and field verification which includes document review and stakeholder interviews. Analysis identified a significant rate of 8% decline in paddy granaries between 2020 and 2021, corresponding to an annual reduction of 3,342 tons in rice production. The research pinpointed physical degradation, socio-economic factors, and climate uncertainties as the key contributing factors to the degradation, decline was corroborated through field verification involving stakeholders. Analysis of policy documents revealed discrepancies in policy interpretation and implementation between federal and state levels. Socio-economic plays a major role in driving farmers motivation to stay in the activity and its ability to replenish human capital. Understanding of degradation is key as it reflect the ability of policy to address the issue and farmers motivation on the ground influencing paddy production thus effecting national rice security.

**Keywords:** Paddy Granaries, Degradation, Spatial Analysis, Urban Planning, Rice Security

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## **INTRODUCTION**

Malaysians rely heavily on rice as a staple food, with rice being a staple food (Hill, 2012). Despite the critical importance of rice, Malaysia has only achieved a 56.2% self-sufficiency level necessitating the importation of 43.8% of its rice from countries such as India, Indonesia, Thailand and Vietnam (Department of Statistic Malaysia, 2023).

The rice industry is a cornerstone of Malaysia's socio-economic activity, particularly in the northern and eastern regions of Peninsular Malaysia. The price and availability of rice significantly impact the livelihoods of Malaysians as the annual consumption per person averaging 73.9 kilograms (Ho et al., 2023) emphasizing the necessity for effective coordination between rural production areas and urban consumption zones (Rahim et al., 2017). Peninsular Malaysia is home to ten primary rice granaries, each managed by institutions such as the Muda Agricultural Development Authority (MADA), the Kemubu Agricultural Development Authority (KADA), and the Integrated Agricultural Development Authority (IADA) (PLANMalaysia, 2023). These institutions play a crucial role in ensuring the sufficiency of domestically produced rice.

This study focuses on KADA, which manages a substantial land area of 23,199 hectares which currently exposed to the degradation, despite the trend is apparent among officials and locals a comprehensive study is yet to be conducted.

Malaysia's long-standing policy, originating from the New Economic Policy era, aims to achieve national rice security by reducing dependency on rice imports with the goals of 80% self-sufficiency level in the year 2030 (PLANMalaysia, 2023). However, recent data indicates an increasing trend in rice imports, with 1.24 million tonnes imported in 2022 compared to 1.16 million tonnes in 2021 (DOSM, 2023) the import value reflect the land degradation situation however there is a lack of spatial understanding for that matters

Therefore, the aim of this study is to identify the rate of granaries land degradation to understand ground situation of farmers perspective on granary condition. Degradation reflects farmers disinterest to stay in the activity and ineffectiveness of the policy deployed. Understanding it, is imperative as this will then contribute to the productivity in ensuring to alleviate the rice security situation in the country.

## **DATA & METHODS**

### **Study Area**

KADA granaries located at eastern corridor of Peninsular Malaysia, in the state of Kelantan Darul Naim. The site is located in proximity to the Kota Bharu which is the main conurbation area for the state of Kelantan and is receiving the development pressure from it (PLANMalaysia@Kelantan, 2023).

It is situated at Kelantan lowland area in the north of state which the region is the most fertile with highest number of populations amounting to

293,420 people within the state of Kelantan (DOSM, 2023). The granaries are in the district of Tumpat and Pasir Mas (see figure 1).

### DISTRIBUTION MAP OF GRANARIES AREA

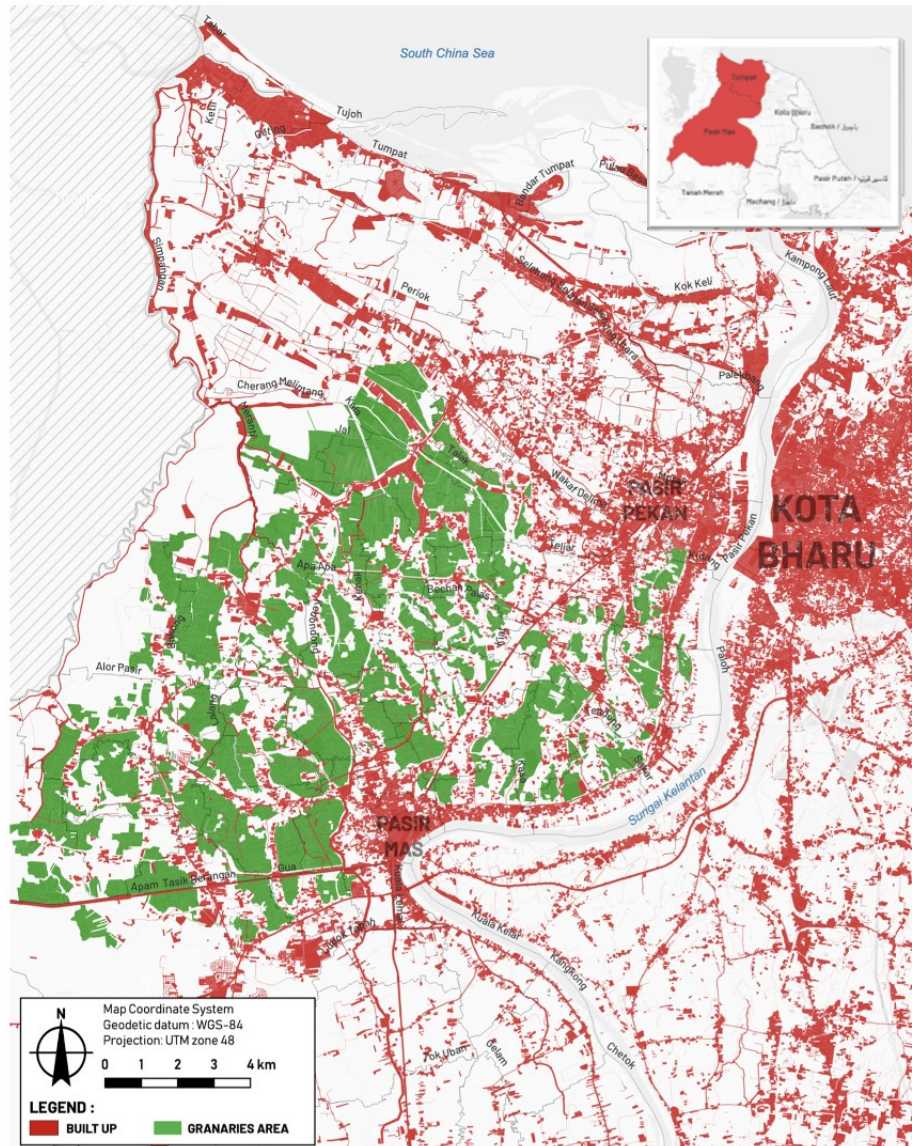


**Figure 20:** Kota Bharu Urbanisation and granaries position.

## Stakeholders

For reliability of the study multiple stakeholder that has relevancy to the granaries is considered, stakeholders identified are as below (table 1).

**Table 12:** List of stakeholders.

| Stakeholder               | Branch                      | Commentary                                                                                                                                                                                                                                                       |
|---------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Industry Players          | Farmers                     | Refers to the person which are doing or involved directly to the activity within the boundary of KADA granaries.                                                                                                                                                 |
|                           | KADA                        | Refers to the management authority which are responsible to distribute the infrastructure, fertilizers, and farming schedule.                                                                                                                                    |
| Federal Government Agency | PlanMalaysia @Putrajaya     | The department responsible to coordinate national development through the establishment of National Physical Development Council (MPFN).                                                                                                                         |
|                           | Ministry of Agriculture     | The department is directly responsible in the performance of the granaries by distributing the yearly allocation, policy shaping, technology sharing and human capital development.                                                                              |
| State Government Agency   | PlanMalaysia @Kelantan      | Refers to the authority to advise state policy through the State Planning Council (SPC) that determine the priority of the land matters.                                                                                                                         |
|                           | Office of Agricultural EXCO | Refers to the authority responsible in managing, driving and allocating involving agricultural capabilities in Kelantan state.                                                                                                                                   |
| Local Authority           | Pasir Mas Local Council     | Respectfully, both authority holds the planning and development policy according to local plan.                                                                                                                                                                  |
|                           | Tumpat Local Council        |                                                                                                                                                                                                                                                                  |
|                           | Penggawa                    | It's the branch of authority that are visible in Kelantan State only. The appointment is made by the kingship monitoring local social development for the district which hold influence toward the local farmers through distribution of the welfare allocation. |

## Datasets

This study involves transition of land from agricultural (He et al., 2011) in which for this study is Class 3 (predominantly paddy fields) to various non-granary land use categories (Chughtai, 2021). The list of datasets is as below (table 2).

**Table 13:** Datasets used to track degradation area

| Datasets       | Source                                                | Format           | Year | Commentary                                                                                 |
|----------------|-------------------------------------------------------|------------------|------|--------------------------------------------------------------------------------------------|
| Granaries Area | Department of Physical Planning (BRFN) @ PM Putrajaya | .shp (Shapefile) | 2020 | The area of granaries is verified and confirmed through the NPP 4 (National Physical Plan) |
| Land Use       | Department of Physical Planning                       |                  |      | Relevant data provided has been cross check within the both of                             |

| Datasets | Source                                       | Format | Year      | Commentary                                                 |
|----------|----------------------------------------------|--------|-----------|------------------------------------------------------------|
|          | (BRFN) @ PM<br>Putrajaya                     |        | 2021      | agency and in-align and verified<br>for the use of studies |
|          | Office of Deputy<br>Director@ PM<br>Kelantan |        | &<br>2022 |                                                            |

Datasets are then methodologically process (Eidsvik et al., 2018) as outlined below (figure 2) ensuring a systematic and accurate approach.

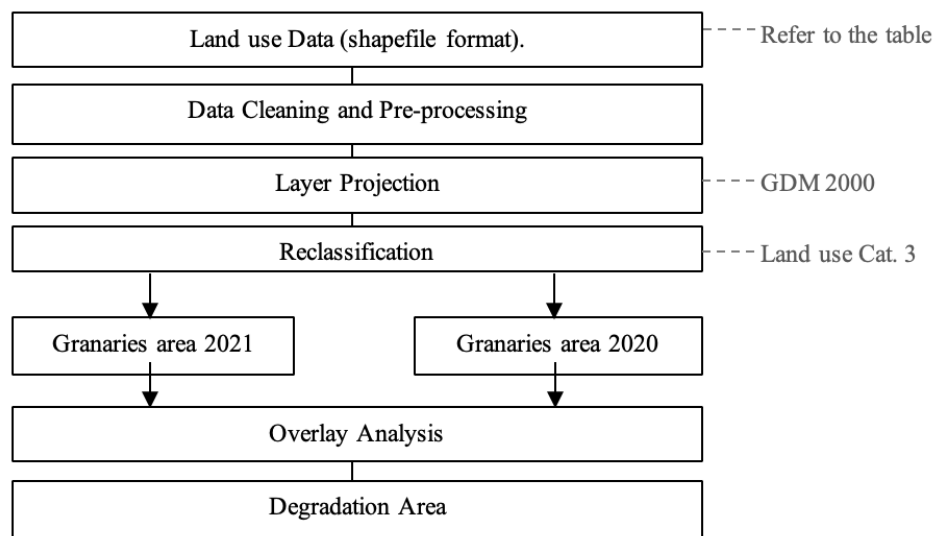


**Figure 21:** Data framework and studies flow.

### Sampling Method

The sampling technique employed was the purposive method, targeting both agency representatives and farmers (Tongco, 2007). This approach was selected to encompass a broad spectrum of perspectives, thereby reducing potential bias in the conducted interviews and enhancing the reliability of the subsequent analysis (Campbell et al., 2020) while referring to spatial analysis to determine the study area in which the land degraded the most in its context to better address the issue and establish coherent understanding of the material based the structured interview question which will outline main concern and input for study purposes.

### Data Integration

As the study involve multiple analysis, an integration the finding from spatial analysis and verification using structured interview as indicated below (figure 3).

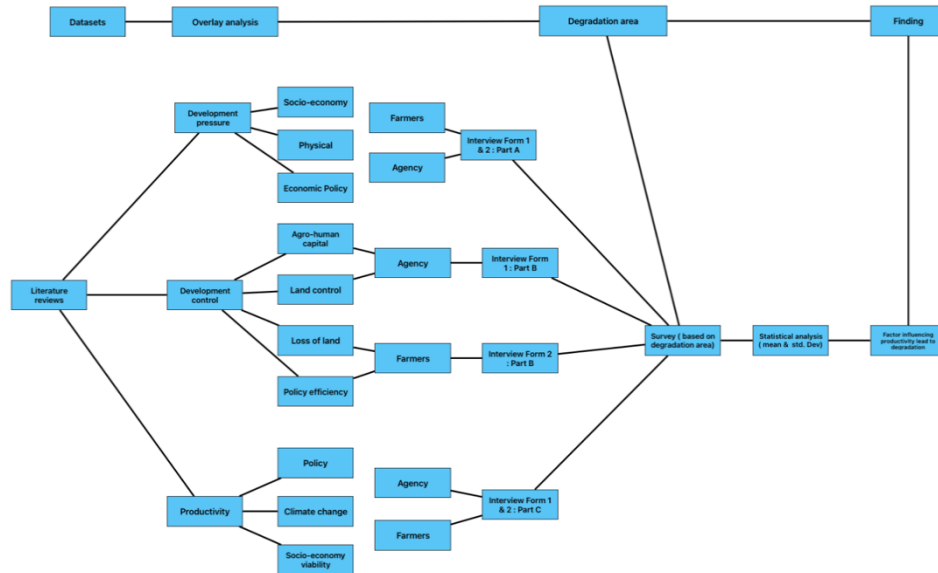


**Figure 22:** Integration of data for land degradation.

## RESULTS AND DISCUSSION

### Rate of Degradation

Based on the analysis, this study found that KADA paddy fields lost approximately 8% of their total land area between the periods of 2020 and 2021. This number is significant because the loss of each hectare of land can adversely affect rice production. To further understand, the 8% loss of that area is equivalent to 2,297.44 hectares, as shown in Table 3.

**Table 14:** Comparison of KADA granaries size between 2021 and 2020

| Year | Size (Hectare) | Commentary                                                                                        |
|------|----------------|---------------------------------------------------------------------------------------------------|
| 2020 | 9,553.43       | Reduction of 2,297.44 hectares according to the land use categorically agriculture class 3 paddy. |
| 2021 | 7,256.00       |                                                                                                   |

The potential loss of approximately 2,297.44 hectares of paddy fields poses severe implications for rice production in Malaysia, a staple food for its population. KADA field productivity, averages at 4.52 tons per hectare (PLANMalaysia, 2023), this reduction could lead to a decrease in rice production by approximately 10,384.43 tonnes annually. Assuming rice prices range between RM 1,200 and RM 1,300 per tonnes (DOSM, 2023), the potential annual income loss from these fields estimated range from RM 12,461,314 to RM 13,499,757. This estimation assumes that the fields operate at optimal levels

without being impacted by socio-economic and climatic factors, which significantly affect productivity.

The largest proportion of KADA paddy field degradation occurs in the northwest area, adjacent to the Golok River (as shown in figure 4), where substantial and collective degradation is evident highlighting the conversion of paddy land to non-paddy land. Furthermore, a significant trend identified is the loss of paddy field areas to infrastructure development. Plans indicate that areas adjacent to main roads are particularly affected, showing linear losses parallel to these routes. Approximately 13% of the paddy field area, or 1,923 hectares, is transformed due to its high accessibility, resulting in rapid changes compared to other regions.

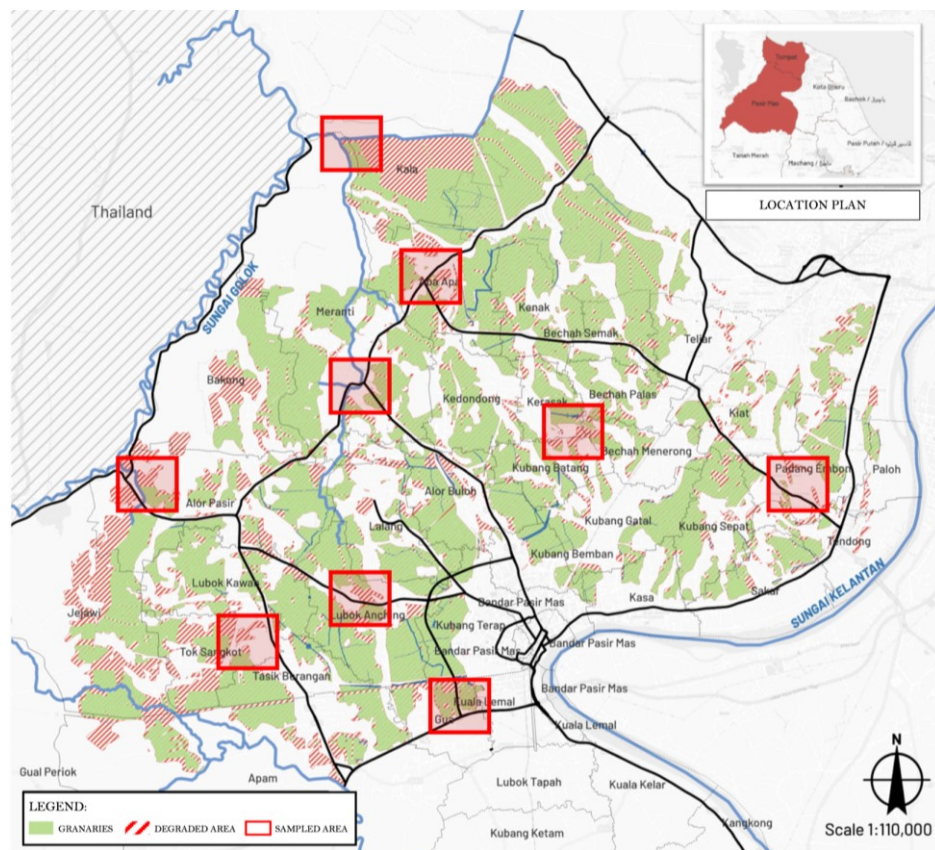


**Figure 23:** Integration of data for land degradation.

## Respondent Demography

Based on the demographic profile presented in Table 5, the majority of the farmers surveyed are aged above 25 years, with a substantial proportion (60%) being over 41 years old, consistent with findings from previous studies. The farming sector remains male-dominated (65%), suggesting that physical attributes still influence labour-intensive activities and productivity outcomes. In terms of field experience, most farmers have been involved in rice cultivation for more than 10 years, reinforcing the generational continuity and strong field knowledge among respondent despite that there is a loop in human capital from younger generation indicating a generational drawback from the activity.

Farmers predominantly manage small to medium-sized plots, with 95% cultivating areas below 20 acres, implying limitations in the adoption of heavy mechanization thus hindering economies of scale resulting in lesser economical gain per plot driving the fragmentation further. All respondents possess land ownership and self-finance their operations, indicating relatively high autonomy. Additionally, 95% of the respondents are full-time farmers, highlighting strong commitment levels, which are critical for sustaining granary productivity. Most farming households comprise 3–5 members, enabling reliance on family labor and reducing operational costs. Collectively, these demographic characteristics suggest a resilient but aging farming population operating under moderate resource constraints and has a lengthy exposure to the changes of fields in the cultivation area.

**Table 15:** Farmers respondent demography

| Respondent       | Citation                                                                             | Criteria        | Percentage | Commentary                                                                                                                   |
|------------------|--------------------------------------------------------------------------------------|-----------------|------------|------------------------------------------------------------------------------------------------------------------------------|
| Age              | Nguyen et al., 2021; Hermawan et al., 2021; Chandio et al., 2018; Tauer, 1994        | <25 years old   | 5          | Majority of the farmers is people above 25 above. The findings in align with other literature document.                      |
|                  |                                                                                      | 26-33 years old | 10         |                                                                                                                              |
|                  |                                                                                      | 34-40 years old | 25         |                                                                                                                              |
|                  |                                                                                      | >41 years old   | 60         |                                                                                                                              |
| Gender           | Kinkingninhoun-Médagbé et al., 2010; Addison et al., 2016; Mishra et al., 2017       | Male            | 65         | Male dominated field, physical attribute play role in higher productivity.                                                   |
|                  |                                                                                      | Female          | 35         |                                                                                                                              |
| Field Experience | Chandio et al., 2018; Khan et al., 2022; Nakano et al., 2018; Erythrina et al., 2021 | <5 years        | 0          | Most of the farmers are generational, meaning their involvement start at young age. Showing good understanding to the field. |
|                  |                                                                                      | 5-10 years      | 20         |                                                                                                                              |
|                  |                                                                                      | 10-15 years     | 40         |                                                                                                                              |
|                  |                                                                                      | >15 years       | 40         |                                                                                                                              |
| Area of Activity | Rahman, 2003; Rahman et al., 2009b; Tu et al., 2021                                  | <5 acres        | 30         | Most of the area tended by farmers or group is under 20 acres. Meaning utilization of heavy machinery is limited and         |
|                  |                                                                                      | 5-10 acres      | 35         |                                                                                                                              |
|                  |                                                                                      | 10-20 acres     | 30         |                                                                                                                              |
|                  |                                                                                      | >20 acres       | 5          |                                                                                                                              |

| Respondent          | Citation                                                                                                        | Criteria         | Percentage | Commentary                                                                                                                                                               |
|---------------------|-----------------------------------------------------------------------------------------------------------------|------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Holdings            | Bello et al., 2020;<br>Koirala et al., 2016                                                                     | Capital and Land | 100        | unimpactful toward planting cost reduction.                                                                                                                              |
|                     |                                                                                                                 | Capital          | 0          | All of the farmers interviewed claim to hold the title and using own capital to stay in the activity.                                                                    |
| Time of Activity    | Munton et al., 1989; Bateman et al., 1974; Conway et al., 2002; Mohd Rashid Rabu & Mohd Dainuri Mohd Shah, 2013 | Full Time        | 95         | Most of the farmers involved in full time, the productivity is hugely affected by farmer commitment to the field.                                                        |
|                     |                                                                                                                 | Part Time        | 5          |                                                                                                                                                                          |
| Number of Household | Panta, 2018;<br>Emran et al., 2021                                                                              | 3-5 person       | 65         | For farmer that use traditional, or hybrid approach higher number of households means significant reduction on labour cost which will lower the overall production cost. |
|                     |                                                                                                                 | >5 person        | 35         |                                                                                                                                                                          |

### Stakeholder Verification

In term of stakeholders, analysis indicates a consensus among both agencies and farmers, acknowledging the presence of development pressures on the KADA territories aligning with the finding of the study.

**Table 16:** Farmers respondent demography

| Respondent | Criteria | Percentage | Commentary                                                                                                                                      |
|------------|----------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Agency     | Agree    | 100        | There is a high level of agreement among stakeholders regarding land degradation, aligning closely with the findings from the spatial analysis. |
|            | Disagree | 0          |                                                                                                                                                 |
| Farmers    | Agree    | 90         |                                                                                                                                                 |
|            | Disagree | 10         |                                                                                                                                                 |

This study supported by literature review and previous analyses confirmed that socio-economic play a crucial role in influencing fragmentation of the paddy field. It acts as a catalyse that drive development of physical while at the same time provide a continuance of sustainability in the activity in time of natural disaster. This is then amplified by policy introduce to the region and its enforcement in orchestrating the paddy fields fragmentation.

Further analysis reveals that the physical aspect is also perceived as significant, with 36% and 45% of agency and farmers respectively citing impacts from land use changes and infrastructure developments. Followed by the third, 5% of respondents from the farmers' side identified climate as a significant factor.

**Table 17:** Factors of Land Degradation

| Factors             | Agency (%) | Farmers (%) | Commentary |
|---------------------|------------|-------------|------------|
| Physical (Land Use) | 36         | 50          |            |
| Socio-Economy       | 64         | 45          |            |
| Natural Disaster    | 0          | 5           |            |

### Land Degradation Impact on Productivity

The findings from Table 7, which identify key factors affecting granary productivity, gain deeper contextual meaning when triangulated with the farmer demographic profile presented in Table 5. The high agreement on “small and isolated plots” as a significant constraint (Mean = 4.87) directly correlates with the reality that 95% of surveyed farmers operate on land areas below 20 acres, limiting the feasibility of mechanization and scale-driven cost reduction.

**Table 18:** Factors effecting granaries productivity

| Factors                                                                      | Citation                                                                                                                                                                                                                                                                         | Mean Score | Level of Agreement | Std. | Rank of Influence  |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------------|------|--------------------|
| Small and isolated plot reduce its productivity                              | Rahman, 2003; Rahman et al., 2009a; Tu et al., 2021; Das et al., 2021; Key, 2019; Sheng et al., 2019; Muyanga et al., 2019; Wu et al., 2005; Nilsson, 2018; Du et al., 2018; Jiang et al., 2017; Hiironen et al., 2016; Zeng et al., 2018; Nguyen et al., 2020; Fan et al., 2018 | 4.87       | Prominent          | 0.72 | Significant        |
| Stable and competent rice price catalyze productivity                        | Rosegrant et al., 1994; Jones, 1995; Dawe, 2001; Nghiem et al., 2002; Kajisa et al., 2005; Rahman et al., 2009b; Dawe et al., 2012; Kompas et al., 2012; Rakotoarisoa, 2011; Prihtanti et al., 2020                                                                              | 4.94       | Prominent          | 0.25 | Highly Significant |
| Adequate paddy field operation infrastructure has influence on productivity  | Antle, 1984; Tuong et al., 2005; Rahman et al., 2009b; Mariyono, 2018; Jimi et al., 2019; Devkota et al., 2020                                                                                                                                                                   | 4.84       | Prominent          | 0.73 | Significant        |
| Climate change and rate of natural disaster event has influence productivity | Knox et al., 2012; Weerasekara et al., 2021; Saud, 2022                                                                                                                                                                                                                          | 4.94       | Prominent          | 0.25 | Highly Significant |

This fragmentation, compounded by the aging nature of the farming population—60% of whom are above 41 years old—reinforces generational drawback related to key factor of limited socioeconomic opportunity to stay in the activity. Similarly, the highest-rated factor, “stable and competent rice pricing” (Mean = 4.94), must be interpreted through the lens of a farming community entirely reliant on self-capital.

The role of infrastructure, another prominent factor (Mean = 4.84), is also shaped by demographic limitations—small household sizes (65% with 3–5 members) and fragmented landholdings hinder collective action for irrigation upgrades or drainage maintenance and further marginalize farmers from benefiting from government support or large-scale interventions. Additionally, while farmers are committed—95% being full-time—the lack of youth involvement (only 15% are under 33 years) poses a risk to future innovation and adaptive capacity, especially in response to increasingly frequent climate-related disruptions, which are also rated highly significant (Mean = 4.94) with climate change and natural disasters accelerating soil erosion, salinity intrusion, and crop failure, the combination of demographic rigidity, economic constraints, and infrastructural inadequacies forms a feedback loop that intensifies land degradation and undermines granary resilience.

## **CONCLUSION**

In conclusion study has confirmed that there is apparent degradation of granaries area on the KADA granaries through spatial analysis and field verification, demonstrating that 8% of the fields experienced degradation between 2020 and 2021. This degradation led to a reduction in rice production by 3,342 tonnes and had financial implications amounting to RM 4,689,048 annually.

Evidently supported by a high level of consensus among respondents concerning the impact of development pressures. Which align with findings from literature reviews. Among the three factors of pressure discussed, the socio-economic aspect is found to have the most substantial impact for degradation of paddy fields, as indicated by both agency and farmer respondents. This is followed by the physical aspect, where concerns about its lasting effects are prominent. The study also notes that the consequence impact is attributed to climate and natural disasters. Lastly, study would suggest a nationwide analysis for the degradation of paddy fields in order to cast a holistic understanding.

## **ACKNOWLEDGEMENT**

The author sincerely thanks all parties involved for input and support especially from PLANMalaysia for data access. Highest appreciation also to *Biasiswa Yang Dipertuan Agong* and Malaysian Institute of Planners for financial assistance.

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Received: 2<sup>nd</sup> May 2025. Accepted: 10<sup>th</sup> September 2025