Innovation to Enhance Efficient and Sustainable Use of Irrigated Land

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Abstract: This study conducted to assess the level of sustainability achieved by effective enough to smart utilization of irrigated land though be through river or underground water resources. The essence of the study surrounds the phenomenon of change adoptability results into consistent growth. Change adoption carries all such practices involved to enhance the productivity of irrigation resource accompanied with varying cropping mixes; by modifying or elimination conventional footprints. Countries like Pakistan, having above 50% of its labor force involved with Agriculture only; cannot afford to own this huge chunk as ill directed, as will result in huge revenue drains from economy and the factor of sustainability cannot be achieved. The economic growth is endorsed only, when the stability is proved perpetual. Hence, the factors of sustainable growth should have to complete the system or process lifecycle, that guarantees the smooth supply of required inputs and later their recycling as raw to assure optimum utilization of all allied elements on optimum grounds.The tendency of farmers and landlords to accept and adopt modern methods of optimum utilization of an irrigated land which is measured through enhanced and long-termyield with enhanced capability of cultivating multiple secondary plants to add value to self-sufficient farmer particularly and the sustainable economy, as whole. Through qualitative inquiry including experimentation, interviews and awareness creating sessions, the study established that majority of the farmers have accepted the change adoption as prosperity factor and had shifted their cropping techniques to modern intercropping practices to utilize an irrigated land and as a pre-emptive measure against potential food security threat.

Keywords: **Irrigated Land, Sustainability, Intercropping, Perpetual Stability, System Lifecycle.**

I. INTRODUCTION

Agriculture occupies pivotal position in country's economy to assure its sustainable development and pushing poverty at lowest level. Its' not the story of back in decades but still in 21st century it is valid for economies like Pakistan, where more than 50% of its labour force is engaged with Agriculture sector (Baloch et al., 2019). The theme of the study surrounds observation, examination and evaluation of all the steps and procedures being followed in agriculture sector, thus to create an impact against the short sighted approach of the around 50% of country's total labor force (*PBS,2018)* as to cultivate or retain sufficient grain as to guarantee their survival for coming one year and paying no attention to any modernization in agricultural practices. They deem change adoptability as a threat to their survival. The concept of sustainability is far away from their lives. Modern agriculture approach means taking risk which might pose threat to the smaller and medium farmer's subsistence. An example of mono cropping background is pragmatic to be most tying factor with grain regions. Practically most of the grain crops like Wheat and Rice do not end up above breakeven line; but the influence factor that it is low risk and gap borrowing options have still kept majority of farmers intact with this mono cropping environment resulting very less change acceptance by very few farmers. Similarly cotton and sugarcane also fall under single and same cropping practices, thus resulting low soil fertility, and resistance to pest's attack, water pouring capability, water retention and accumulation of many unutilized elements turn the soil towards the barren status (Chapagain et at., 2018). The farmer is the only entity who bears these consequences being completely exposed and having direct impact on his life. His livelihood is solely dependent on the earnings from the crop for which he had worked for a complete season and if he does not have any gain, he fails to sustain his family (Hodges 2005). Farmer lives with very ties options, either to continue traditional mix of agricultural practices or to try a bit riskier selection of adopting modern agricultural practice; no doubt, the latter one is difficult and tough, but eventually the only workable option to improve his life style. He can come out of the violent round of budding grain for his family needs at the cost of better pay packet; since his buying power is augmented through adoption of multi cropping method (Gebru, H. 2015).

II. RATIONALE

For an agrarian economy, where specifically on account of occupying above 50% of country's labor force engaged with agriculture, the livelihood of farmer portrays a very pivotal picture and eventually impacts on the country's poverty level. On the other side, Family Farms observed as continuity factor and the contrary the non-family farms leads to innovation ad sustainability (Sofie Joosse a, 2017). The lack of education, awareness, motivation, market fluctuation and water availability issues are the tying factors to conservative cropping practices, thus the acceptance and adoptability of Modern Human Resource Practices are proposed to be the solution for their sustainable livelihood. The beauty of the field observations defeats these dragging elements and not a single data recorded rejecting the phenomenon of accepting and implementing the modern practices and mixes.

III. TYPES OF AGRICULTURE PRACTICES

The agricultural practices inhabit fundamental responsibility in Farmer's future and his survival. This ultimately is going to portray country's economic position towards strength and self-sufficiency. The degree of Agricultural sustainability determines the country's prosperity and sustainability (P Srivastava, 2016). These transactions include Uni-cropping$_1$, Crop Rotation$_2$, Poly Cropping$_3$, Soil Resting$_4$, Raised Bed Cropping$_5$, Tunnel Farming$_6$, Drip Irrigation$_7$, Sprinkler Irrigation$_8$,

Center Pivot Irrigation[9], Surface Irrigation[10], Seepage irrigation[11], High Density Farming[12], Roof Top Farming[13] and many more. Uni-cropping[1], when single same crop is planted year after year, continuously. Crop Rotation[2], when a series of different types of crops in the same area in sequenced seasons. Poly-cropping[3], is a technique, when two or more crops are grown in proximity. Soil Rest[4], restoring soil fertility by giving soil a rest. It helps in reducing soil erosion and increases soil fertility and crop yield. Raised bed cropping[5], Raising cultivation bed to control water and fertilizer usage with options to cultivate more than two plants at the same place. Tunnel Farming[6], is the cropping technique that provide controlled environment and pest control, result boosted per-acre yield, by cost controls and support in off-season production. Drip irrigation[7], Drip irrigation has the potential to hoard water and nutrients by allowing water to roots of plants, either above or buried below the surface. It saves up to 60% of usual water usage. Sprinkler Irrigation[8], Water is distributed by overhead high-pressure sprinklers or guns from a central location in the field, Center Pivot Irrigation[9], Water is distributed by a system of sprinklers that move on wheeled towers in a circular pattern. Surface Irrigation[10], Water is distributed over and across land by gravity, no mechanical pump involved. Seepage Irrigation[11], is a method of irrigation by which the *water* is delivered to the plant root zone. High Density Farming[12], it's a new concept of crowding plants as assured way of High production. This is observed in raising the productivity of High-value commercial crops. Rooftop Farming[13], is also known as Vertical farming, mostly adopted for raising fresh produce on the top of buildings. It is the most effective form of hydroponics techniques using specially by Greenhouses.

IV. PAKISTAN-A PREDOMINANTLY AGRARIAN ECONOMY

Agriculture sector of Pakistan has conventionally trailed an unmanageable track due to poverty of agricultural resources. Many studies are carried out to find environmental, economic and social sustainability of agriculture in Punjab, Sindh, KPK and Balochistan provinces of Pakistan. The studies are based mainly on secondary data, covering the period from 2005-06 to 2012-13, each aspect of sustainability is analyzed using selected indicators. Crop diversification, soil salinity, use of organic and inorganic fertilizers and pesticides, were the indicators considered for environmental sustainability analysis. For economic sustainability analysis, change in overall crop production and stability of crop production were the indicators used. Employment of rural labor force and food security, were indicators used for social sustainability analysis. The findings from these analyses have revealed a tendency towards unsustainable agricultural production in all provinces. This was caused by over use of inorganic fertilizer, pesticides and groundwater for irrigation in Sindh and Punjab.

The lack of sustainable agricultural production in KPK and Balochistan was due to limited use of fertilizer and pesticides in some areas and altogether no use in other areas. Use of groundwater for irrigation in the coastal areas of Balochistan further reinforced agricultural un-sustainability. Thus, it has to be deduced from the findings of the studies that there are regional differences in agricultural sustainability in Pakistan. (Farhad Zulfiqara, 2017).

Pakistan's economy is largely based on its agricultural produce. Water is therefore a critical resource for its sustained economic development. Enjoying all four seasons with moderate weather suitable for every kind of plant cultivation is a natural advantage Pakistan is consecrated as of its geographical placement. The freezing and the extreme high temperatures prevail at different places of country, thus create a healthy & supportive climate conditions for Agriculture to grow & flourish, having its unique strength. World's best water sustainability solution to these resources via water distribution canal system (Indus Basin Irrigation System), which was later extended as, "Indus Basin Replacement Works". The extensive undertaking involved the construction of (two major dams, five barrages and eight link canals.) Pakistan's IBIS has emerged as the largest closest irrigation system in the world. The IBIS comprises of three large dams, eighty-five small dams, nineteen barrages, twelve inter-river link canals, forty-five canal commands and 0.7 million tube wells. In monetary terms, this network is the biggest infrastructure enterprise of Pakistan accounting for approximately US$ 300 billion of investment. (Source: TBL (Triple Bottom-Line Sustainability Advocacy-A specialized platform of APR).

Agriculture as household activity is the built-in forte to Pakistan as a whole, but unfortunately, the country where our almost every economic sector is fostering on either direct or indirect outputs of Agriculture, is now a days' facing grave crunches of Water; Change is Climate due to Global Warming, Deepening & erratic underground sweet water availability, ongoing elimination of basic seeds, pushed dependency on imported hybrid seeds (High Yield, negligible nutrition Value, no future value), a passive observer role by government on Agriculture and no control on implementation side of the Policies for fair distribution of resources & market ruling is one or the other way have become bottle neck to this sector.

Ultimately the Farmer (Central character of the Show) is facing worst ever conditions with every passing day; the situation is pushed to the extent that now a days' the Central Character is observed striving for sufficient wheat growing as to assure that he & his family won't die with hunger for the coming year; on the contrary the Agriculture share to GDP is on accelerated pace of growth. The scenario, so developed is guiding us to adopt modern techniques of Agriculture Production, in parallel the policy of profit sharing in between Farmer & Land Lord, so as the due profit share can be passed to the farmer, accordingly will result High Motivation & Innovation adaptability for Cost reduction and high yield crops with more life cycle as compared to traditional crops that are cultivated every year & yield once or hardly twice a year.

V. PROBLEM STATEMENT

Pakistan, being an agrarian economy have sizeable magnitude of its crops contribution to GDP, as the studies have proved that Cotton, Wheat and Rice have significant and positive correlation with the GDP, whereas the Sugarcane does not, hence the government should introduce subsidy plans to invest for development of the modern cropping techniques as the yield and

the lifecycle of these may be lifted to a significant level (Abdul Rehman, 2015). After extensive scholarly literature review and on ground observations, this need to be investigated that:

- Why the Agriculture Sector is still being carried out on obsolete practices resulting Farmers are still living below poverty line?

VI. AIM AND OBJECTIVES OF THESTUDY

Based on the longitudinal experimental approach, this study aims to establish the farming methods that are most suitable for local Farmer keeping in view his stake alive to not to compromise his and family food requirements, which he is already been maintaining by following through traditional cropping methods. Moreover, its' an attempt to develop his subsistence farming to make it more efficient and to find out the dynamics that influence their adoption of modern farming methods to eventually attain food security and prosperity at individual as well at large on national level.

The study plots a route to accomplish subsequent objectives.

Objective 1: To review and identify prevailing agricultural practices.
Objective 2: To make growers familiar with modern agricultural practices and their benefits to all stakeholders.
Objective 3: To provide solutions to for smooth adoption of modern agricultural practices as prosperity factor for their sustainable survival.

VII. RESEARCH APPROACH

Since the model is driven through longitudinal experiment, hence the farmer seen is more convinced, when he has observed innovated practices acquiring positive add-ons to the stakeholders end. The practical execution approach of the study has eliminated all doubts that were creating bottlenecks in accepting the any new addition to the system by the farmers; the reason determined, was only the fear factor of anticipated loss by this change adoption.

Researcher started the transaction with Poly-cropping on some portion of land. All the steps taken were completely exposed with a view to break the fear factor. With this approach the researcher achieved multiple benefits, such as trust of farmers regarding no hidden practice and resource utilization along with their impacts on plants grown in proximity.

VIII. AGRICULTURAL SUSTAINABILITY

Agricultural sustainability is the foundation for uninterrupted growth, that eventually is inevitably required for economic stability. The Economic, Social and Environmental factors hold the foundation of Agricultural Sustainability (FarhadZulfiqara,2017).

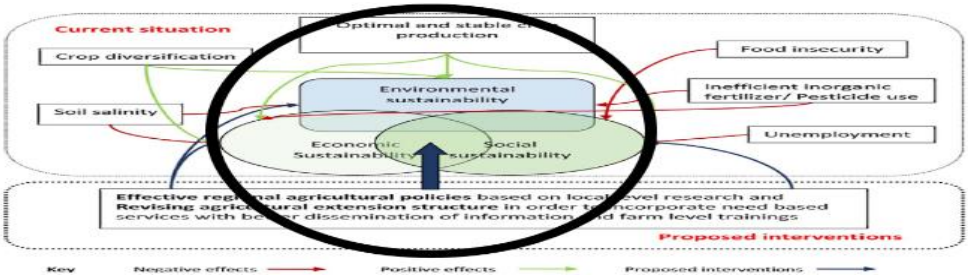
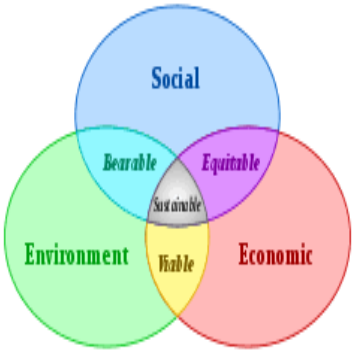


Fig. 1

Source: *Zulfiqar, F., & Thapa, G. B. (2017). Agricultural sustainability assessment at provincial level in Pakistan. Land use policy, 68, 492-502.*

IX. WHY IS TO BE SUSTAINABLE

The longitudinal experiment based study will answer the basic factors contributing towards sustainable survival by managing Triple P Model, where the sustainability is attained by keeping balane between all environmental, social and economic factors. It will only happen when:



- Planet (***Environmental Factor***) deemed to be sustainable, when surroundings are Viable and Bearable.
- People (***Social Factor***) will be sustainable, when masses of society are supportable and evenhanded
- Profits (***Economic Factor***) deemed to be sustainable, when are Viable and Equitable

Fig. 2

This study will draw a realistic guideline for farmer to either continue with old and outdated agricultural practices or to reshape the transactions based on modern technology and R&D based procedures, that surly maintain the optimum utilization of resources with increased land productivity. The phenomenon of grain holding is no more the future of the farmer; but the modern farmer enjoys the financial liberty, thus have plenty of food choices and life necessities options in hand.

The entity of Agri-Entrepreneur can only be developed with sustainability, which is not possible without adoption of modern and innovated agricultural practices and this adoption is worthless without accepting it completely. It means there is positive correlation between Sustainability and Change acceptance.

X. DRIVERS TO ADOPTION

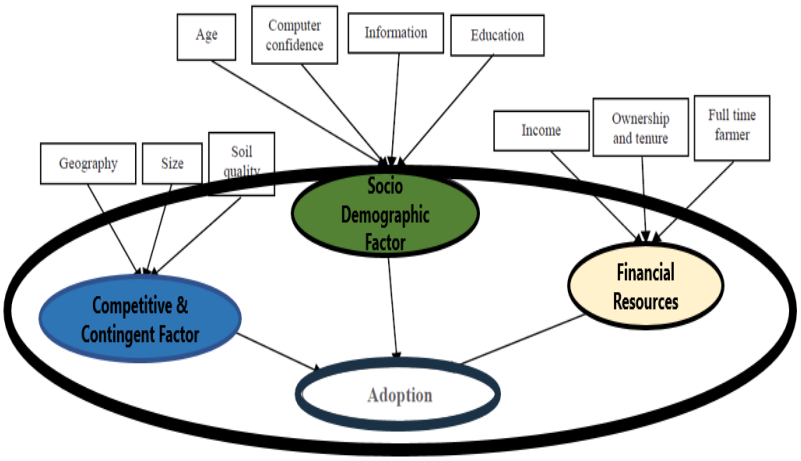


Fig. 3

Source: *Pierpaoli, E., Carli, G., Pignatti, E., & Canavari, M. (2013). Drivers of precision agriculture technologies adoption: a literature review. Procedia Technology, 8, 61-69*

The Adoption observed is controlled by three factors; (1) Competitive and Contingent Factor, that found relying on Category, Size and Soil Quality of the Field, (2) Socio Demographic Factor, staying on Age, Computer Confidence, Information and Education of Farmer and (3) Financial Resource Factor based on Income, Ownership & Tenure and Full Type Farmer of Field. Eventually the Adoption is lined with proper management and alignment of these factors to each other.

The study background stays on innovation policy that resulted with two approaches latterly can be successfully shared while intervention is taking place; (1) the innovation process that seems to be a conventional, short sighted approach of finding short-term resolution to specific problems (push approach) and (2) the network building process where policy engaged multi-level, multi-disciplinary processes (pull approach). In two areas, the policy activities appeared to have contributed to increased revenues of farmers. The study shows that a balanced arrangement of both push and pull approaches and a strategic linkage between the policy transactions and external growth – government policies and involvement – are decisive for a productive agricultural transformation. The result also indicates that the balance processes require a confined freedom to turn up, and the balance approach needs flexibility to house the complication of each innovation (Edmond Totina, 2020)

The world is facing food security issues, and to sustainably overcome the increasing demand for food (FAO, 2014, 2016), agricultural structures need a transition from the overriding industry agriculture models to lead for invention, autonomy, competence and affordability (Prost et al., 2017). The sustainable agriculture that conserves land, water, plant, animal genetic resources, and must be environment friendly, non-degrading, precisely correct, economically feasible and socially acceptable" (FAO, 1989).

Recent efforts are based on pluralism approach, thus co-existing and co-evolving of development and endorsement of alternative forms of agriculture is the solution. The critical challenges facing a transition to become more sustainable in agricultural systems are often related to resource competition (Bennett et al., 2014; Elzen et al., 2012; FAO, 2014, 2016). These challenges inherently extent to multiple natural resource management systems and linked with ecosystem services (Bommarco et al., 2013; Tittonell, 2014; Saint Ville et al., 2015).

XI. ISSUES TO INNOVATION

For successful adoption of any innovated practice, farmers' input market integration may contribute to high extent and can influence the sustainable use of agricultural land (Ayat Ullaha, 2020). To evaluate this proposition, study conducted based on input provided by farmers to assess the potential constraints on quality inputs, prices, and addition information. A multistage random sampling technique adopted to collect data from 395 respondents. We then compared differences among adopters and non-adopters, the results indicate that there is a considerable difference between the adopters and non-adopters when considering their perceptions of asymmetric market information. Non-adopters are doubtful of inflated prices, the non-availability of price lists, and adulteration of agricultural inputs, unbalanced input weight and the supply of low-quality alternate commodities (e.g., fertilizers and pesticides) in place of the recommended commodities in the markets. Our results call for the reformulation and implementation of appropriate policies to ensure transparent and equal information sharing among farmers engaged in input markets and for the provision of timely and quality inputs assured by regulatory checks and price checks. Free availability of information on innovations and appropriate oversight over markets appear not only to motivate farmers to adopt agricultural technologies but also to influence more sustainable land use practice.

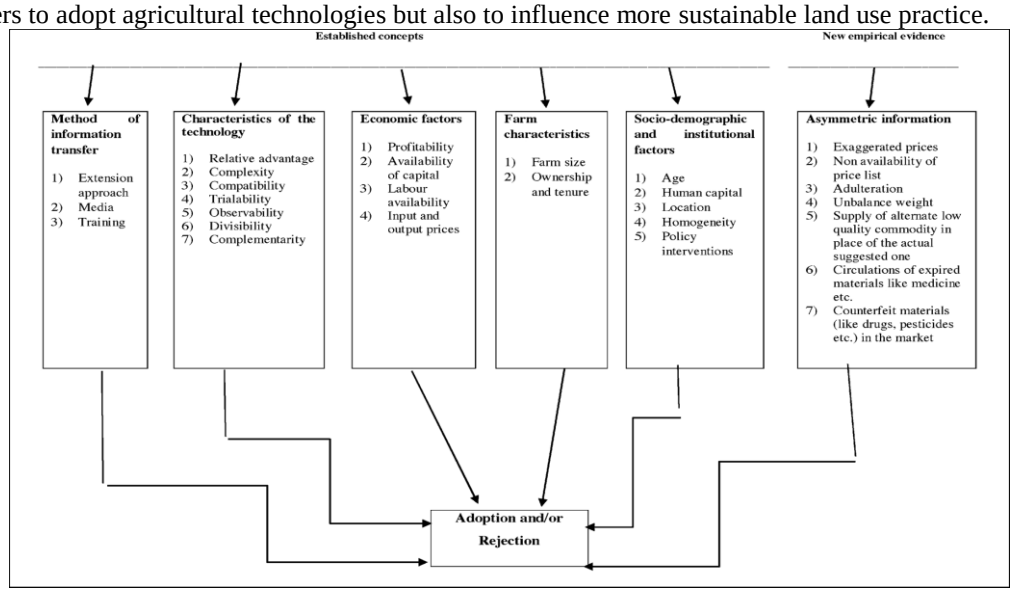


Fig. 4
Source: (Rogers, 1995, 2003 and Kumar et al., 2018) generated empirical evidence—Factors affecting adoption and/or Rejection

Since the study aims at to determine level of proposition among Innovation and sustainability; then, on the basis of observations and experiments executed in field, it is established that there is strong correlation between level of Innovation and sustainability. Being fact the agriculture occupies pivotal place in country's economic stability, hence the Farmer as an entity need to be focused more in terms of their level of education, awareness, supply of agriculture allied tools and machinery under subsidized pricing schemes in parallel to availability of seeds and fertilizers towards organic theme as to get add-ons from farmer towards country's economic growth as well as to counter future food security issues and nutrition level maintained productions.

XII. RURAL & URBAN ADOPTABILITY GAP DISCUSSIOIN

The decision to adopt innovation in agriculture is observed complex. Few critical factors identified by researcher are influencing adoption decisions, such as information transfer$_1$, the characteristics of the technology$_2$, economic factors$_3$, farm characteristics$_4$, socio demographic$_5$ and institutional factors$_6$ (Kumar et al., 2018). However, there required is experiential evidence on the influence of information irregularity on farmers' decision to adopt innovations. This Study therefore investigates whether information irregularity in improved technology or innovation in imperfect markets hampers Farmers' decisions to adopt innovations. The adoption of innovation is low among rural farming community, whereas the Urban Farming communities found progressive towards innovation with high tendency. This also establish the need for better resources and the supply of quality input (Thierfelder et al., 2015). The low adoption of innovation technology has been associated with information irregularity that hamper farmers' acceptance for innovations and consequently limits farmers' adoption, farm productivity and sustainable use of farmland (Ogutu et al., 2014).

Connecting farmers to markets will surely be a strong mechanism to improve farmers' admittance to input as well as other productivity-enhancing services (Omondi et al., 2017). From the available scholarly literature it is confirmed that access to agricultural expansion and marketing information are the main factors that significantly affect farmers' adoption decisions (Arshad et al., 2016). The primary constraint related to the economic feasibility of market-oriented farming is that farmers remain in low input and low output systems with several other input services limitations (Brown et al., 2018). Farmers commonly depend on traders for information, which usually results in irregularity and biased information along with poor market services (Mirani and Memon, 2011). Framing input market services include services that provide farmers with materials such as seeds, fertilizers, pesticides, and machinery required for better farming (Alwarritzi et al., 2017). Therefore, in this study, in accord with this scientific view, we assumed that irregular information influences the farmers' decision to adopt innovations. Based on this statement and the adoption theories discussed earlier, this study propose to capture the

influence of irregular information on farmers' decision to adopt innovations in imperfect markets that affect the sustainability of agricultural land use on high note.

The study observed that the farmers, who have accepted the change, are near to prosperity factor and had shifted their cropping techniques to modern practices for utilization of their irrigated land effectively and as a pre-emptive measure against potential food security threat. The resource management and market intelligence play a very important role in this whole study, as the abundance production will push the market to an unwanted trend which will ruin the efforts of farmer even though he has adopted and well managed the whole transaction. Information $Transfer_{1,}$ Extension approach, Media and Training, etc.

Characteristics of $Technology_2$, include relative advantage, complexity, compatibility, trial ability, observability and divisibility. Economic $Factors_3$, include, profitability, availability of capital, labor availability, input and output prices. Farm $Charateristics_4$, include farm size, ownership and tenure. Socio $Demographic_5$, include age, human capital, location, homogeneity. Institutional $Factors_6$, include Policy Interventions. Hence, in parallel with adoption of innovated farming, the farmers have to have a very vigilant eye on his inputs and the results timing with potential market trends. Being the fact, the only reason of moving from old and non productive farming techniques towards new and modern cropping techniques is to assure a sustainable future for farmer that evolve this major labor force segment of a country towards innovated mind set with a vision to forecast future demands and market trends. A well calculated effort can only be taken by the farmer who has proper information of market, whether, different fertilization and irrigation techniques, simultaneously at varying cost effective and competitive edge in market.

XIII. CONCLUSION AND POLICY RECOMMENDATIONS

Existing studies on agricultural information diffusion mainly disregard the pressure of information irregularity in the imperfect competitive market on the farmers' decision to purchase inputs for the adoption of agricultural innovations for sustainable agricultural land use, which is a gap that this study fulfils. The experimental results exposed that farmers perceived the input prices and quality as unsatisfying services provided by the domestic markets. However, this non-satisfaction was mostly because of an information irregularity that resulted in the farmers' failure to adopt innovations. Farmers were suspicious of inflated prices, the non-availability of price lists, adulteration, unbalanced weight and the supply of alternate similar-looking commodities in place of the actual suggested commodities, which effected their decision to adopt innovations and hence affected their farmland use Prices should also be frequently regulated, and one price for each commodity should be ensured for every farmer across the region. Regulations should be formulated and their implementation should also be ensured by the local regulatory authorities to sustain and boost agricultural land use.

Controlling adulteration, unbalanced weight, the supply of alternate similar-looking commodities in place of the actual suggested. Therefore, it is recommended to formulate effective regional agricultural policies based on local level research and revise agricultural extension structure in order to incorporate need-based services with better dissemination of information and farm level trainings. In addition, broad policy recommendations are made for sustainable agricultural development in each province under the scope of the study.

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