Interaction of Energy and Environment with Agriculture:Strategy for Risk Management

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***Abstract*— Rural population depends on agriculture that is major source of income for livelihood. The agricultural work is sensitive to variation of external uncontrollable environmental parameters as well as some controllable parameters that are vulnerable to risk on return on investment. Therefore this study has been undertaken to achieve the goal for balancing application of inputs to meet these challenges towards sustained growth in productivities (Yield per hectare). The Analysis is based on identifying linkage of agricultural productivity with energy intensity, rainfall and consumption of fertilizer by statistics and mathematical formulation of the system dynamics. Study is focused on selected sample states in India, UP, Punjab, Haryana and Chhattisgarh which are dependent on agriculture and prone to climate variation. The observation reveals that better energy management increase more yield per hectare and cultivation become independent of weather variation if energy efficiency is optimum. Secondly, study observed that energy requirement directly varies with irrigated area, intensity of agricultural machineries utilization and no. of cold storages whereas; this varies indirectly with production of Fertilizer, transportation of agricultural products to market and other works. Thirdly, irrigated land is more productive with increased energy intensity correlated to climatic condition. Thus, the study identified that uncertainty in favorable climatic condition and energy availability is challenge to the farmers to sustain growth of productivity. This study finally accepted management strategy to develop knowledge production driving parameters among the farmers, developing infrastructure for Information Technology, complete rural electrification covering all panchayat area and exploiting available potential resources of renewable energy.**

Key words: Environment, energy, agriculture, biogas, irrigation

I. Introduction

In India, Population growth is 21.54% percentages per year [8], but availability of cultivable area of land is finite. This is an important issue in respect of sustainable agricultural productivity to meet growing demand of food products, if climate become unfavorable then there is uncertainty in the productivity, another issue is changing social pattern in different parts of India that has impact on changing pattern of productivity. However,inspite of all uncertainties, natural resource and environment required for sustainable agricultural productivity is most favorable in India because of geographical location in the world except in the arid region of western and some parts in central India. The major resource is water for irrigation and power generation, fossil fuel for power generation and fertile land to facilitate multiple cropping with the advantage of supporting tropical climate. However, the development of climate change during the past decades, variation of soil's marginal productivity not in consistence with marginal consumption of fertilizer and reliability in adequate energy supply cast a shadow of uncertainty over the agricultural work. Risk involved in expected assured return of investment is now considerable in many states that need evolving risk management strategies to ensure positive return on investment balancing inputs to agriculture and agricultural output to market. This paper attempt to analyze linkage between different variables of input to agricultural work and its variation during the last decades to focus on the uncertainty in the long-term period, then justified the risk management strategies to utilize the natural resources according to requirement without leaving any scope of wastage to save sustainability of agricultural productivity. This study finally recommend need of knowledge development among the farmers about efficient use of energy for watering the field adopting modern technology in combination with scientific methods of fertilizer application ,weather report circulation among stakeholders. to ensure sustained growth in productivity, policy in developing infrastructure for Information Technology application in all villages for this purpose and exploiting available potential resources of renewable energy. The discussion starts with introducing the methods of study by statistical and mathematical analysis in section 2,followed by development of strategy for risk management in section 2,finally concluding the study by summarizing the discussion.

II. Methodology

The methodology is collection of data from web portal of agricultural, meteorological and power departments, and then obtained reliable and effective information by processing data with statistical methods. Then Hypothesis postulated based on the observation of agricultural work pattern which is justified by mathematical and statistical analysis to know the relationship between the variables that have impact on agricultural work. Finally, Risk management strategies evolved based on the result of the analysis.

A. Hypothesis

It is assumed that energy conservation and energy consumption pattern in agriculture is possible to control if knowledge of climate of the region and farmers activity is developed by technology application

B. Climate and agriculture

Before beginning the discussion, it is necessary to know the linkage of agricultural production with different entities; the climatic condition in India is one such important entity since agricultural production is the open system within the environmental envelope. The graphical presentation in fig. 1 & 2, are based on the data obtained from Indian Metrological Department about departure of annual rainfall (mm) from normal precipitation and annual minimum temperature rise during 1981 to 2010 in all India. [3] It is observed that trend of mean temperature is increasing whereas; trend of annual Monsoon rainfall (mm) is decreasing during last decades. Therefore, the agricultural production is vulnerable to such changing pattern of climate that need suitable measure for adaptation since requirement of water for sustaining productivity from the finite area of cultivable land is the only option to meet the challenge of variation in weather pattern.

C. case study

Chhattisgarh and Haryana have been selected for the analysis because of contrasting weather pattern, geographical location and consistency in agricultural work. While agriculture in former state is mostly depended on rainfall due to poor irrigation system, better irrigation infrastructure in the later state help to sustain production even during the period of low rainfall. Statistical observation reveal that arable land in Chhattisgarh depends on rainfall due to South – west monsoon where irrigation facilities is available to 22.6% of cultivable land.[9] Whereas Haryana has better irrigation facilities because of its better irrigation infrastructure involving canals, reservoirs and shallow tube well and deep tube wells. Graphical representation in figure 4 indicate linear variation of rainfall and agricultural productivity curve in case of Chhattisgarh, where as, the productivity curve is not varying linearly with the rainfall curve in the case of Haryana in figure 4. The availability of better irrigation facilities in Haryana

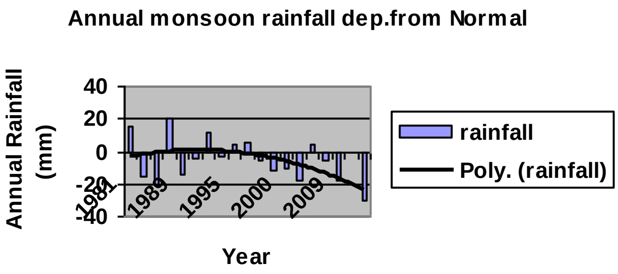

Fig 1Annual Monsoon Rainfall(mm) departure from normal

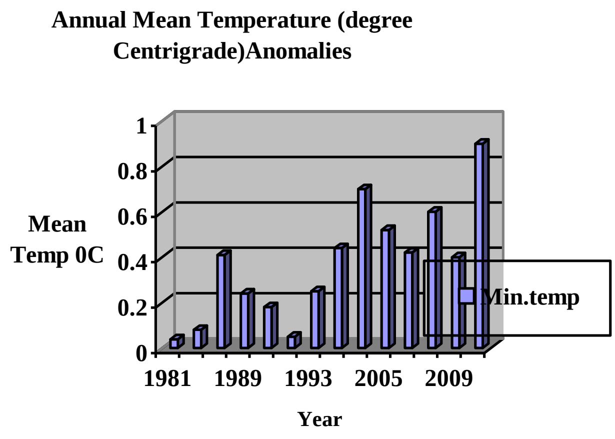

Fig 2.All India Annual Mean Temperature (degree Centigrade) anomalies

attributes to sustaining productivity even when rainfall is not adequate. However, this trend is reversed in the case of Chattisgarh fig. 3, which support the hypothesis yield per hectare depends on rainfall pattern in the respective location; this is typical case of rainfall and productivity linkage because of low percentage of irrigated land. Therefore, better irrigation facility will increase yield per hectare in irrigated land and probability of crop failure for climate change will be minimized

D. Agriculture and fertilizer

The most important analysis is to find correlation between fertilizer consumption and agricultural production. Index of Agricultural productivity growth (base year 2000-01) has been compared with Fertilizer consumption growth index in Table 1. Growth of both indexes is uniform till 2004-05 and then pattern changes with increase of fertilizer consumption that indicate productivity increase is not proportionate to usage of fertilizer. Therefore, observation of fertilizer consumption and variation of agricultural productivity trend during 2000-01 to 2008-09 implies growth in crop production can be maintained efficiently by scientific methods of fertilizer usages.

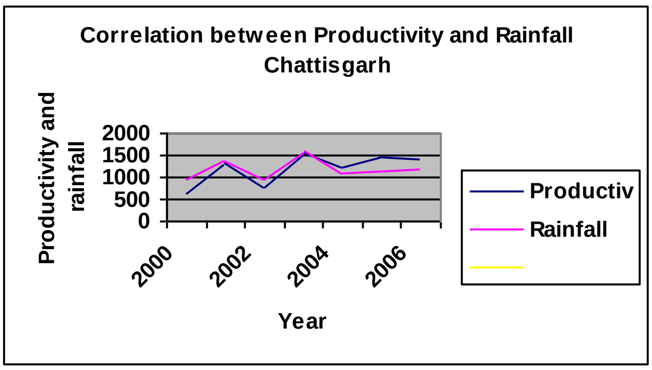

Fig 3. Agricultural productivity vs. rainfall in Chhattisgarh

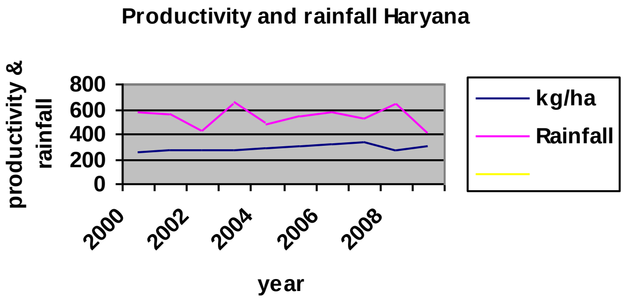

Fig 4. Agriculture productivity vs. rainfall in Haryana [1]

Therefore, production of fertilizer need be balanced with its consumption by monitoring fertilizer application. This observation therefore, justifies fertilizer application and agricultural productivity policy will help to regularize usage of fertilizer in field, production standardization and conservation of energy in production of fertilizer.

Table 1 Fertilizer consumption and Productivity (base year 2000 -01

	2001-02	2004-05	2006-07	2008-09
Yeild/Ha	1.06	1.01	1.07	1.17
Consumption	1.04	1.102	1.296	1.49

E. Energy linkage with agricultural work

Study on the electricity consumption, agricultural production and irrigated area in agricultural activities of Chhattisgarh, Haryana, Punjab, UP, Tamilnadu, Gujarat and Maharashtra states reveal interesting relationship between the above-mentioned entities in Figure 6. The trend of production curve is uniformly varying with electricity consumption curve for all the states under consideration except in the case of Punjab, Haryana and Thailand where pattern of producing crop is different. The pattern of variation of these entries for Tamilnadu display electricity consumption is more than actual requirement for irrigated area and the crop production, because of free power supply to agriculture, the farmers neither care for hours of operation in operating pump nor about exact size of required pump-sets for their cultivated area. In case of Gujrat, similar condition is in practice where flat rate tariff and availability electricity supply to irrigation encourage farmers to consume electricity more than actual necessity, where as, in the case of UP where flat rate of tariff is effective, the electricity consumption in agriculture is not proportionately same to that of expected requirement of irrigated land though the increasing trend of agricultural production line is almost parallel to line of irrigated area. This mismatch between the entities is attributed to losses in electricity consumption. The above observation in the graphical presentation fig. 7, corroborate the view in studies of expert [5] that farmers does not bother about wastage of water and power because of zero marginal cost of pumping under flat rate tariff. There is risk of declining ground water level due to excessive drawal of water. Another issue is electricity supply utility could not maintain their profitability in future by increasing cost of electricity supply with the increase in fuel cost though demand in agricultural sector increases in leaps and bound. It will not be easy to change the tariff Therefore; the maintenance of feeder line will pose a problem due to revenue loss that will affect reliability in power supply. Therefore, if the farmers continued to utilize electricity without caring for efficiency in energy consumption, then maintaining the reliability in electricity supply system will be at stake that in turn will become risky to operate the pumps and will have damaging effect in agricultural production. According to a study by the expert on relationship between energy –irrigation [5], hours of operation of pump is more important for irrigation when the good quality power is required at critical time of harvesting the crop. Nevertheless, the energy is driving input for growth of agricultural productivity (Figure: 7).

E. Restriction on hours of Operation of pump sets

Let Yw = Q/h,
If water allotment for a irrigated land is X,
Then, hours of operation is h = X/Yw h/ha
For a land area of Z hectare
Hours of operation is Z*h

Therefore, hours of operation may be regularized to save water and electricity.

The graphical presentation in fig. 5 displays variation between agricultural production efficiency and its contribution

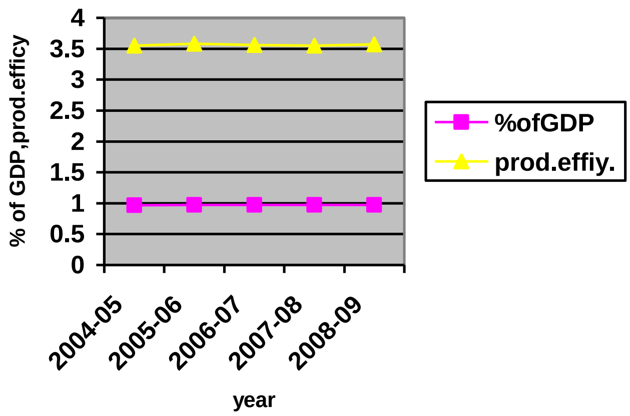

Fig 5 Production efficiency vs. growth of GDP (%)

to growth of GDP in India. The pattern is uniformly horizontal over the years 2004-05 to 2008-09; such relationship between these parameters if connected to energy consumption pattern on the other side, display reverse pattern of variation since 2004-05 between energy consumption in agriculture and agricultural production in the graphical presentation in fig. 7,. Since electricity consumption is directly related to irrigation intensity and that in turn is correlated to agricultural production efficiency, these graphical analyses implies that a part of energy input is not contributing to growth in rural economy that implies wastage of energy. Moreover, this pattern of energy consumption will drive water consumption beyond actual necessity for crop cultivation. Thus, ground water depletion will lead to scarcity of water in the long term period. Thus the hypothesis is justified by the above statistical analysis for the following reasons. Good quality of energy service in agricultural sector implies adequate power supply at the time of critical soil moisture content. The energy conservation is possible by the management of regulating watering time each day for an optimum period to meet the requirement of soil moisture criticality, thus reducing energy consumption in pumping water from deep tube well or shallow tube well.

- Next, some states offer incentive to agricultural tariff that encourage farmers to consume electricity without caring for its efficiency and conservation norms.

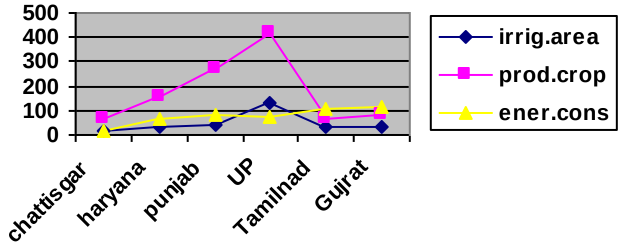

Fig 6. Trend of energy consumption, irrigated area and crop production

Fig 7 Energy consumption /ha vs. yield per hectare [1]

III. Mathematical Analysis

Reference to an analysis [4] on the relationship between the variables in agriculture and the weather at any region by mathematical method, the important information emerged.

If Yi is yield per hectare of the land,r is the annual rainfall departure in a area and t is the mean temperature, then expected climate in the area for agricultural growth can be expressed as , $C = r/t > 0$, let X is the crop characteristic

$$Yi = A*x + c*Yi + k \quad (1)$$

Where, A= soil characteristic is the co efficient and k is growth supporting application which is a constant.

Since Ci is continuous variable, Marginal effect on crop yield can be expressed as

$$ME = Dy/Dc = fn\ldots \quad (2)$$

After computation of (1) & (2)

$$fn= Yi[c+1]2 \quad \ldots \quad (3)$$

Then marginal change in yield per hectare with marginal change in climate © will vary from previous year by a factor [c+1]2, this implies yield per hectare will be affected by square of value in (3) ,that the yield per hectare will decrease if C become< 1, yield will increase if C >1.

IV. Risk Management

Now the discussion has reached at the stage of assessing risk in agricultural work for the variation of different entities. It is now clear that climate of a region and availability of energy are the two major factor of uncertainty that is required to be managed. The cause of uncertainty in the process is lack of knowledge about the entities probability of variation from normal state of activity. Agriculture is the systematic scientific process. Therefore, application of scientific methods in resolving the issues and the dissemination of knowledge among farmers about controllable and uncontrollable variables is best strategy to avoid uncertainty in the system.

A. Risk analysis

Probability of risk in agriculture covers the following functional areas -

A Production Risk

B Market risk

C Financial risk

The study reveals that probability of uncertainty at each stages of the agricultural work is high because of uncontrollable climate adversity and the controllable reliability in electric supply. Since marketing of agricultural product is depended on production capacity and storing at the warehouse and cold storages, the variation in productivity due to uncertainty will equally affect the marketing subsystem and financial sub system on account of chain reaction. Fertilizer application also need scientific method, unless fertilizer is applied scientifically, there is risk of losing stability in production that is controllable. Financial, marketing and production sub systems are in close loop within the agricultural system, the development of uncertainty at any stage in the sub system will have impact on the other sub system in chain action. Unless agriculture production reaches expected target productivity, there is less probability of further investment by the farmers. Therefore; the model risk management can be presented in figure 8 below. The model indicates that deficiency of input to any sub system will have possibility of risk in the functioning of all sub system since production; marketing and financial sub systems are in close loop of the entire agricultural system. Since energy input is controllable that has linkage with irrigation, a better infrastructure will minimize risk. While uncontrollable climate that has linkage with energy resource and irrigation, minimization of risk is also possible by adaptation methods. Energy security become better by decentralized power generation from renewable energy resources, specially, utilizing biogas plants technology. The agricultural sub systems are in close loop which are vulnerable to uncertainty but controlling methods by IT, knowledge development programme and better infrastructure will minimize uncertainty. The model suggests scientific methods need be included in agricultural support mechanism. This is controllable methods to minimize uncertainty that is increasing knowledge about unknown future events. Firstly the driving input to supporting mechanism need be developed.

Power is driving input to information and communication technology as well as water and fertilizer. Therefore, power supply infrastructure development with ICT and water management is the controlling methods that are connected to production, marketing and finance sub system. The uncontrollable climate and weather is different across the country, Long-term weather forecast need be disseminated to farmers by application of advanced Information and communication technology in collaboration with meteorological department [1] in order to create awareness among the farmers about the impending regional weather situation across the country. then it is essential to develop information network adopting information technology to disseminate information covering every nook and corner of the rural India Since spreading communication network need infrastructures for energy distribution at the villages.

B. Adaptation method

Simultaneous with forecasting of weather efficiently, the policy of better water availability and storage infrastructure is necessary to meet challenge of weather adversity. The strategy will be to develop Community based Water storage and irrigation policy, since the management of irrigation at community level will overcome difficulties of electricity availability and cost of pumping water for small and middle land owners.

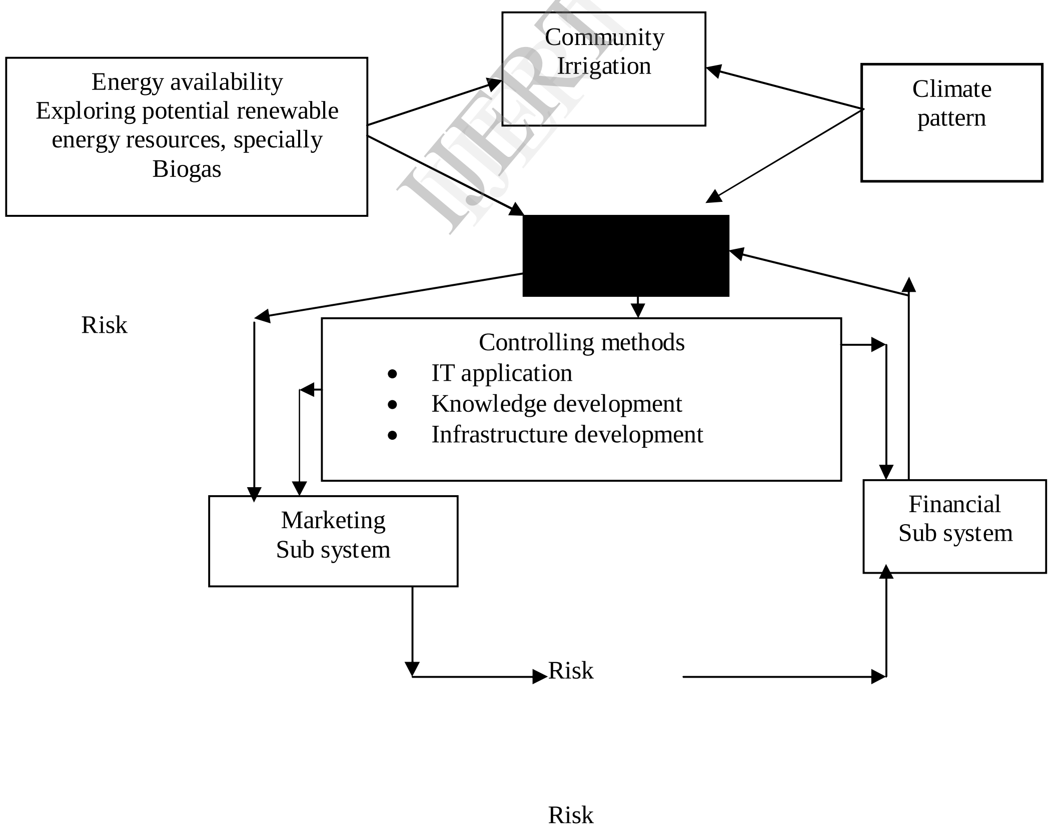

Fig 8 Model Risk management in agricultural work

The profile of landowners has changed during last decades because of fragmentation of land in a family. There are more small and medium level landowners than large plot holders. This method will also save water because there will be central community controlled system to operate the pumps for irrigating the field according to the requirement in agricultural work. The pumping of water and related work may be included in MNEREGA scheme. Nevertheless, there is risk of perishing agricultural product in case of unfavorable weather if proper cold storage and warehouse are not available. The planning of warehouse and cold storage infrastructure across the state need be planned in marketing sub system according to expected production and distribution capacity. Thus infrastructure development simultaneously needs electricity supply in the area.

C. Knowledge development

It has been explained in the previous section that uncertainty arises due to lack of knowledge about methods of resources utilization; the prime resources are water and energy that farmers should have knowledge especially in the operation of pumps for irrigation and application of fertilizer according to requirement in consistence with prevailing weather condition. The institutional development is necessary to disseminate knowledge to the farmers to reduce wastage of energy, fertilizer and water to lower weight age of uncertainty in the scale of planned target of agricultural productivity. The training programme for dissemination of knowledge on irrigation and energy consumption to farmers in collaboration with institutions and Panchayat, best infrastructure of Information and communication network and training faculty for field demonstration is a necessity for risk minimization. Post training follow up programme may include feedback and regular correspondence with farmers to clarify their doubts will add value for improvement of training programme .Last of all monitoring the agricultural work to know improvement in reality is essential.

D. Energy security

Strengthening feeders and installing proper capacity of distribution transformers with electronic surveillances and loss control together with exploring potential renewable energy resources and its implementation in the states will eliminate effect of uncertainty due to energy availability from grid electricity supply. Development of information network is depended on availability of electricity supply, so best electricity supply infrastructure in all panchayat is essential for reducing uncertainty in agricultural system. Since potential fuel resources for bio gas plants are wastes from agricultural field, dairies and backyard poultry farms, the policy to develop infrastructure for power generation from biogas at every block level will meet demand for energy requirement in agricultural work.

V. CONCLUSIONS

The above discussion focused on risk in agriculture due to climate change, improper water management, improper fertilizer application, wastage of electricity and inadequate electricity distribution infrastructure. There is close linkage between energy consumption, climate of the region and irrigation that variation of any one parameter will equally affect the other parameters in the system. This has been displayed in block diagram figure 8. Agriculture will be independent of climate change effects if the energy supply and irrigation infrastructures are developed. Energy utilization must follow the rules of energy conservation and efficiency for sustainable agricultural productivity. Greater resilience to draught is possible by maintaining soil moisture content with skill of managing water and power supply by controlling key operating mechanism as tariff and feeder connection, The study recommends that policy need be formulated to develop community controlled irrigation system covering small and medium level landowners under one roof to prevent wastage of power and water. The alternative measure is to raise the flat tariff at higher rate to discourage farmers from unnecessarily operating the pumps and application of drip irrigation to save wastage of power and water. Knowledge dissemination to farmers in the area of operating the pump sets and water management by organizing training program at panchayat level with the application of information and communication technology will help to reduce risk of crop failure due to climate change. The infrastructure for communication network should be better for creating awareness about impending weather and long term climate condition among farmers. This facility for better irrigation and communication network need better electricity supply infrastructures. Therefore, more decentralized power generation out of potential renewable energy resources need be explored; especially bio gas plants installation at every block across the country, the feedstock resources is available in abundance for utilization of this technology.

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