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Greater Mekong Subregion

Capacity Building for Efficient Utilization of Biomass for Bioenergy & Food Security in the GMS [TA7833-REG]

FINAL REPORT:

Feasibility Study for a Pilot Investment Project to Scale-Up the use of Biochar from Rice Husks in Climate-Friendly Rice Production, Viet Nam

September 2013

KEY DATA

Name of Project:	Capacity Building for Efficient Utilization of Biomass for Bioenergy & Food Security in the GMS TA-7833 REG
Contractor:	Landell Mills Limited (LML), Bryer-Ash Business Park, Trowbridge, Wiltshire, BA14 8HE, UK Tel: +44 1225 763777 (www.landell-mills.com) in consortium with: Nexus Carbon for Development (Nexus), #33 E3 Sothearos Blvd, Corner St. #178, Phnom Penh, CAMBODIA (www.nexus-c4d.org)
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PART 1. INTRODUCTION

1.1. Project review

As part of its wider support to the Greater Mekong Subregion (GMS) regional cooperation program in agriculture implemented by the GMS Working Group on Agriculture (WGA), the ADB supports the 'Capacity Building for Efficient Utilization of Biomass for Bioenergy and Food Security in the GMS (TA7833-REG)' project. The project provides support for activities in Cambodia, Laos PDR and Viet Nam with the expected outcome of improved efficiency of pilot biomass utilization projects through the application of integrated approaches to bioenergy and food security development.

In delivering the above outcomes and impact the project will deliver the following outputs: (i) Enhanced regional cooperation on bioenergy development that fosters and safeguards food safety; (ii) Pilot-tested climate-friendly biomass investment projects, for more extensive implementation; (iii) Strengthened capacity for the efficient use of biomass, and; (iv) Development and dissemination of knowledge products.

The major taks of the project are feasibility and design study for a pilot investment project to scale-up the use of biochar from rice husks in climate-friendly rice production in two provinces – one in the north and one in the south of Viet Nam – along with supporting due diligence.

Stakeholders and the Government of Viet Nam identified the use of rice husk to produce biochar for use in climate-friendly agriculture, including SRI as a priority for wider adoption.

The biochar sector in Viet Nam is new and the development of SRI rice is rapidly emerging as Viet Nam seeks to adopt a more climate-friendly approach to rice production. The ensuing pilot project aims to prove that the demand for biochar-related products in SRI is sufficient to warrant the utilization of rice husk produced by rice mills. The pilot will test the viability of creating a small enterprise as a partnership between farmer associations/ cooperatives and rice mills. The pilot will provide experience through which an investment model can be refined for inclusion within a subsequent investment phase.

Within the Mekong delta rice plots are significantly smaller and the options of using biochar will require assessment of the viability of local biochar kilns linked to available biomass residues. Options in the Mekong delta may include smaller kilns or multi-purpose improved cook stoves (ICS) that provide for cooking, in addition to a mix of ash and char by-products. The Mekong option will be defined during the feasibility study.

1.2. Scope

Location and time of study: According to the TOR, two provinces will be selected as Thai Nguyen and Can Tho. After considering all items, the consultant proposal was accepted to change to two other provinces which representing for rice production and processing: An Giang and Hanoi (including formerHa Tay).

The reason for selecting these provinces as below:

- ❖ Among pivotal rice production areas, An Giang is the first consideration because it is second rice basket (603,900ha) of Mekong River Delta. It is also located nearby the centre of the Southern West and maitaining diversification of rice processing factories at big, medium and small scale. In this province, several pilots of SRI and friendly rice production toward low emission of Carbon including bio-char application program.
- ❖ In the North, Hanoi can be considered for selection because it has large area under paddy rice after merging with Hatay province. Hence, there has been some rice processing bases at medium scale and rice husk has been ultilising for variouspurposes such as bio-carpet in poutry husbandry, cooking, char product applied for substrait of seedling and soil fertility improvement. SRI has been also strengthening in Hanoi recently, especially in former Hatay.

PART 2. PILOT LOCATION, STAKEHOLDERS AND WORK UNDERTAKEN DURING FEASIBILITY

2.1. Location

As refered above, Hanoi and Angiang were selected as site for feasibility study

2.2. Works undertaken, stakeholder and method

The FS has been conducted through 4 steps : desk study, field survey, analysis and reporting. During FS implementation, the consultants maintained close link to NPI and NFP to ensure all activities are follow the plan as well as requirements as proposal.

- **Desk study:**VIDECOs will review of all documents that related to the content of the FS, including some of project documents, biochar information, rice mill plants in two selected provinces. These information helped the consultant group to design survey and report writing as well.
- **Data collection:** Based on the result of desk study, VIDECOs will develop 3 questionnaires sets which include one for rice miller, one for farmer (rice producer and rice husk user); one for local authorities. Questionnaire set will cover data for preparation of socio-economic baseline, poverty reduction and social strategy, stakeholder perception and preferences for shaping the design of the pilot and its implementation, gender and ethnicity disaggregated, biomass related products including biochar enhanced products and the attributes, willingness of woman union in pilot participation, capacity building needs…

2.3. Method for selecting correspondents:

- **Provincial and district officers:**collecting data from 3 officers of provincial level (Hanoi and An Giang); 11 from district and community level (Annex 1 and 3)
- **Rice millers:** 24 from two selected provinces who represented for small, medium and big scale plants (Annex 1 and 4);
- **Rice producers and rice husk users:**123 key farmers randomly selected from two selected provinces who are self milling rice for daily demand (Anex 1 and 5)

Data source and collection:

- **At the Central Level:**
    - Project's documents, project's designing paperwork, project's logical framework, project's annually consulting reports(CPMU)

- Documents of technical process, biochar production and consumption from rice husk, results of research study from using biochar in agriculture, targets and evaluating results of environmental impacts in using biochar in agriculture (Institute for Agricultural Environment, Institute for Soil and Fertilizer, Agriculture Reserach Institute for Southern Central Coat belonging to VASS)

❖ **At Province Level (2 provinces – Hanoi and An Giang):**

- Information in agricultural production in general. Focus on rice producing information. The usage of fertilizer, organic fertilizer, biological fertilizer, biological and coal use agricultural waste as fertilizer in the district. Information of districts producing rice as RSI, rice producing biochar establishment. Provincal poverty reduction and social strategy. General informations about ethnicity, customs in rice producing and consuming (DARD)
- Information on land use planning, environmental issues and environmental protection activities, prevention of climate change, evaluate of the effectiveness of the environment of biochar production from rice husks; consulting reports of the environmental issues, agricultue and rural. Ministry monitors and evaluates environment in agricultural producing (Environmental Management office belonging to Provincal Department of Natural Recources and Environment)
- Information of producing facilities and consuming biochar products in the province: the producing process; producing devices, producing volumes and annual consumption, the predicted social product development (Some main coal producing and consuming facilities and in the province)

❖ **At District Level (5 districts – Dong Anh & My Duc - Hanoi; Phu Tan, Cho Moi, Chau Phu – An Giang):**

- Information about agricultural production in general, which focus on rice producing, on the use of fertilizer, organic fertilizer, biological fertilizer, biochar and utilizaton of agricultural waste as fertilizer in the district. Information about the communes producing rice following SRI process; about the rice processing and biochar producing facilities; about the sustainable poverty reduction strategy of the district. General information about ethnicity, its traditions and customs in rice production, labor division and rice consumption. Selection of communes for modeling (Department of Agriculture and Rural Development, Statistics Department, Department of Industry and Trade)
- Information about land use planning, environmental issues and environmental protection activities, prevention from global warming of the district, evaluation on the environmental effectiveness of biochar produced from rice husk; The reports on environmental issues, scenarios against climate change, standards for

monitoring and evaluation of the district environment. (Department of environmental resources of the district).

- Information on biochar production and consumption facilities in the district: manufacturing processes, production devices, and annual production and consumption volumes; forecasting the opportunity to develop biochar (Some facilities of biochar production and consumption in the district, Department of Industry and Trade).

❖ **At Commune Level (10communes - 4 from Hanoi and 6 from An Giang):**

- Information on agricultural production in general, which focus on rice production; on the use of fertilizer, organic fertilizer, biological fertilizer, biochar and utilization of agricultural waste as fertilizer in the communes. Information about the villages and households producing rice in SRI, the sustainable poverty reduction strategy of the communes.
- Information on commune land use planning, environmental issues and environmental protection activities, prevention from climate change, assessment on economic efficiency and environmental protection of biochar produced from rice husk. General information about ethnicity, its traditions and customs in rice production, labor division and rice consumption. Selection of group and households applying model (People's committees, agriculture and agricultural extension officers, statistics officers of the communes).
- Information on biochar production and consumption facilities in the commune: production devices, and annual production and consumption volumes; forecasting the opportunity to develop biochar (Some biochar production and consumption facilities in the district, Department of Industry and Trade).
- Households Survey: 123 households were surveyed on rice production techniques; understanding of processing and using techniques for organic fertilizer, biochar, biogas, and assesment on environmental and economic efficiency of biogas production and biochar produced from rice husks; labor division by gender;the needs of households on the utilazation and development of biochar.

Data analysis

Information and data collected in field survey were analyzed by using following method:

- **Inherit:** obtaining research results, data, and secondary data that officially posted on mass media, reports of related agencies and project office.
- **Statistical method:** Survey data were analyzed by using statistical software: SPSS, Excel...

- **Specialist:** Report was made by obtaining opinions from experts, experiences person in biochar development field.

2.4. Reporting

Base on the table system, documents, survey data, opinions, and report outline the report was made accordingly to requirement.

PART 3. BIOMASS AVAILABILITY AND RICE HUSK FLOW

3.1. Potentiality of Byproducts from crop production sector

Up to date, there has been no official data on byproduct from each specific crop, according to the estimation from Department of Crop Production and Institute for Agricultural Environment (IAE), the rice straw and rice husk from rice production accounts for 1.0 and 0.2 time compared to crop yield respectively. It means that to get 1 ton of rice productivity, the amount of rice straw produced is 1 ton and rice husk is 0.2 ton. For other crops, production of 1 ton productivity release an average quantity of 1.5 tons residue.

With the above estimation, the byproduct in 2011 of Hanoi is 1,847.86 thousand tons, of which rice straw and rice husk took a biggest proportion and occupied by 65.88 and 13.18%. In An Giang, the total is 4,775.42 thousand tons and rice straw occupied by 80.49%, next to rice husk 16.10% (Table 1a; chart 1, 2 and 3).

Table 1a. Byproduct from production of major crop in Hanoi and An Giang in 2011

Crop	**Hanoi**			**An Giang**		
	Productivity (1000 ton)	Total residue (1000 ton)	% of the total	Productivity (1000 ton)	Total residue (1000 ton)	% of the total
Rice	1,217.30	-	-	3,843.60	-	-
Rice straw	-	1,217.30	65.88		3,843.60	80.49
Rice husk	-	243.46	13.18		768.72	16.10
Maize	111	166.50	9.01	76.4	114.60	2.40
Soybean	50.5	75.80	4.10	0.6	0.90	0.02
Sweet potato	46.5	69.80	3.78	6.5	9.80	0.21
Cassava	38.2	57.30	3.10	25.2	37.80	0.79
Groundnut	11.8	17.70	0.96	-	-	-
Total	**1,475.30**	**1,847.86**	**100.00**	**3,952.30**	**4,775.42**	**100.00**

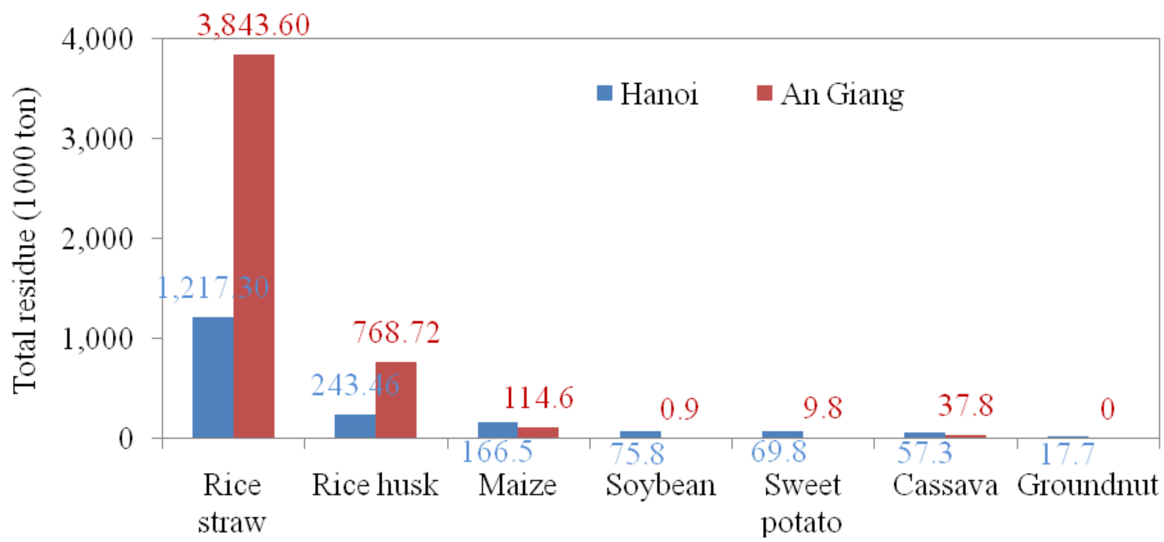

Chart 1: Quantity of various by-product from Ha Noi and An Giang in 2011

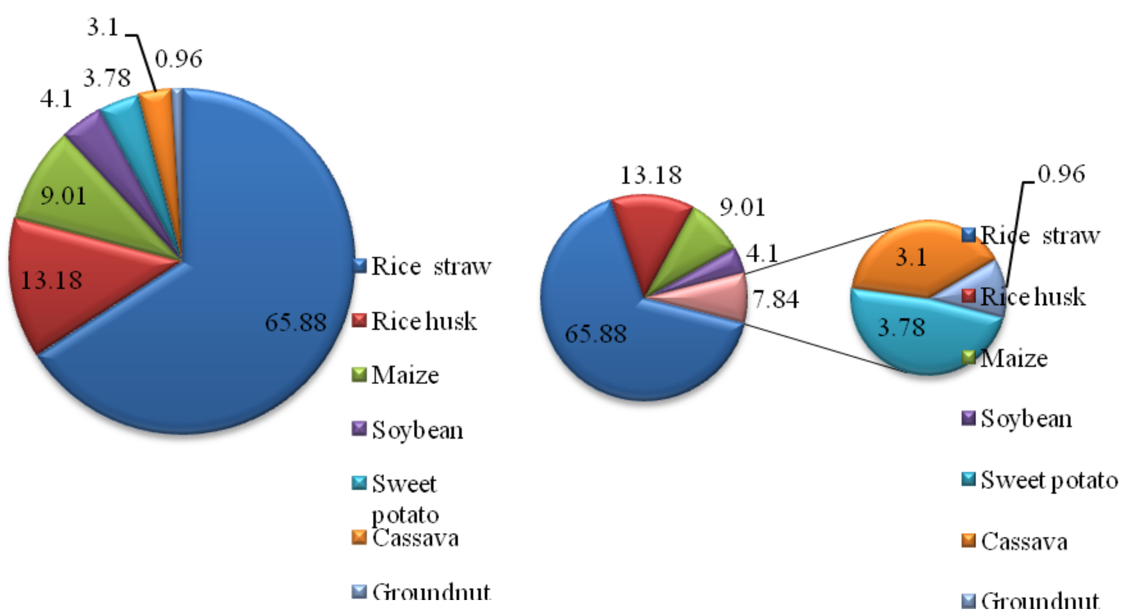

Chart 2: Proportion of total by-product from main crops in Ha Noi

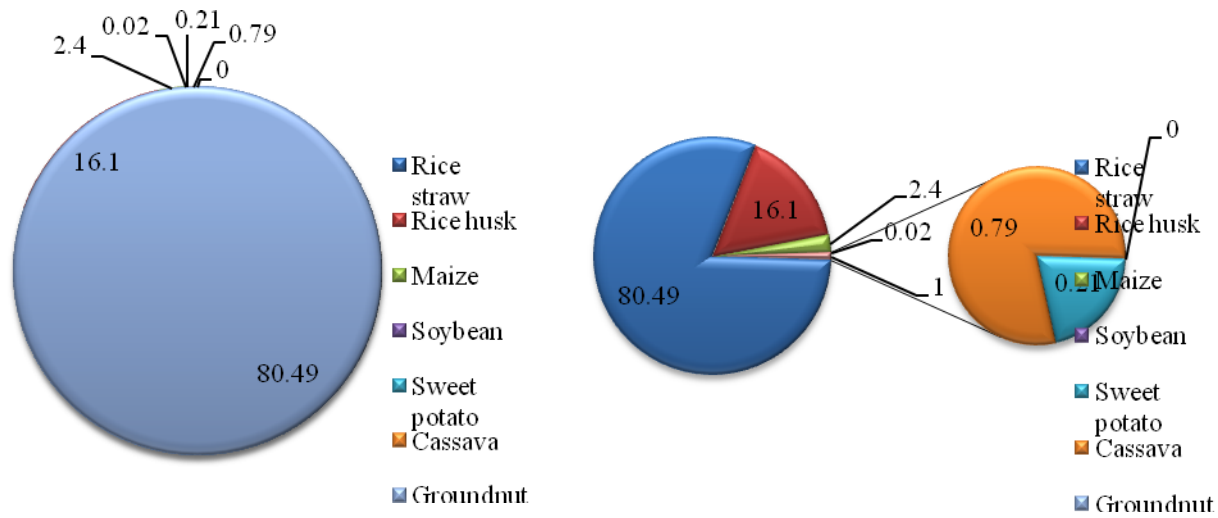

Chart 3: Proportion of total by-product from main crops in An Giang

3.2. Current status of rice husk use and flow

In Hanoi and An Giang, the survey team has collected 9 secondary reports and interviewed 3 leaders, 4 experts from the central agencies; 14 local leaders; 24 rice millers and 123 farmers as husk producers and users from 10 communes under 5 districts (Annex 1-5).

Survey findings showed that husks as well as other byproducts produced from cultivation have great potential. However, exploitation and use of these resources by farmers is limited. On the other hand, due to the characteristics of the production system (surface area, cropping systems, etc.) and services (product commercialization, milling etc.), rice husk as well as other byproducts in agriculture are consumed is different ways. However, in general, most of rice husk is used for different purposes by farmers.

In **Hanoi**, like other localities of the Red River delta, the production scale of 2 survey districts (Dong Anh and My Duc) is very small (5.24 sao of nature land/ household). Much of the land is used for rice production (100% of survey households produce rice on 92.4% of crop area). The other 7.6% of the area is used for other crops such as corn, soybeans, and vegetables. Given the average rice output of 194kg/ sao, rice production by households is estimated to be around 931kg/ harvest, equivalent to 1862kg/ year. Rice husk produced thereof is approximately 366kg/ year.

Survey findings showed that 100% of farmers take their rice productivity to the millers' to mill into rice for daily consumption and sale. 88.47% of the farmers responsed that they retained husk back after milling, accounting for the same propotion of husk retained back. There was only 11.53% farmersresponsed to leave husk at milling base.Among 88.47% farmer took the husk back from milling, 16,94% of them used husk for covering land surface (accounting for 15.25% total husk of the area), 41.67% for ash producing (accounting for 37.29% total husk),8.33% for bio-carpet (accounting for 6.78% total husk), 11.67% for cooking (accounting for 10.53% total husk) and 14.86% for composting (accounting for 18.64% total husk).

Of the total farmers responding to buy husk from milling base, 59.01% farmers used husk for producing ash for tendering rice nursery or vegetable/ or direct fertilizing on the land surface for improving soil porosity serving vegetable production (accounting for 6.24% total husk), 34.43% for use as bio-carpet (accounting for 3.32% total husk) and 6.56% is utilized for fuel (accounting for 1.97% total husk)- Table 1b; chart 4 and chart 5.

Table 1b: Summary of rice husk used by various purposes

Husk use purpose	Ha Noi		An Giang	
	Percentage of respondents (%) *	Percentage of total rice husk produced (%)	Percentage of respondents (%) **	Percentage of total rice husk produced (%)
Husk retained by Farmers				
Direct use for land covering	16.94	15.25	-	-
Ash production	41.67	37.29	11.11	2.98
Bio-carpet	8.33	6.78	5.56	1.19
Cooking	11.67	10.53	83.33	20.83
Composting	14.86	18.64	-	-
Brick production and rice drying	-	-	-	-
Husk retained by Miller				
Ash production + direct use for land covering	59.01	6.24	-	-
Bio-carpet	34.43	3.32	-	-
Cooking	6.56	1.97	43.75	11.72
Brick production and rice drying	-	-	56.25	63.28
Total husk retained by Farmers and Mlliers				
Ash production and direct use for land covering	-	58.78	-	2.98

Bio-carpet	-	10.10	-	1.19
Cooking	-	12.50	-	32.55
Composting		18.64	-	0
Brick production and rice drying	-	-	-	63.28

Note:*: calculating for appropriate group of user ultilized husk retained by farmers and millers

**: % of the total husk retained by both farmers and millers.

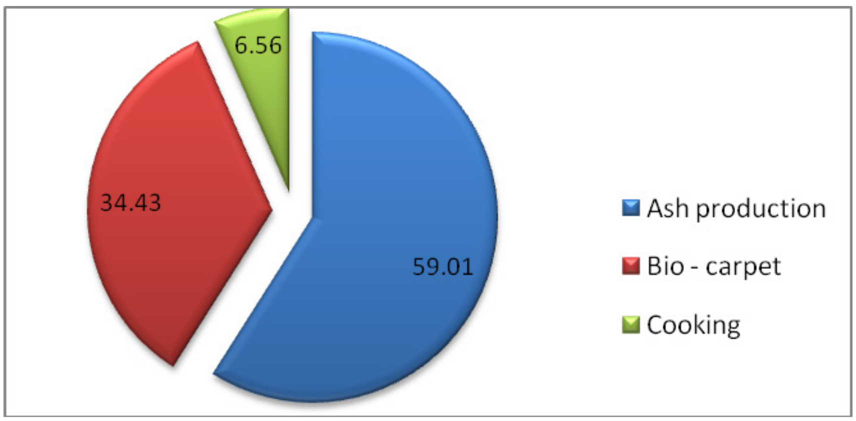

Chart 4: % farmer used husk retained by millers for various purposes in Hanoi

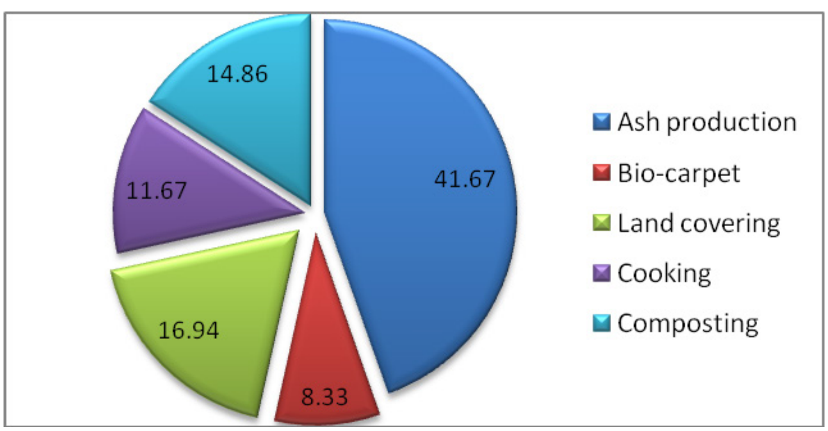

Chart 5: % farmer used husk retained byfarmers for various purposes in Hanoi

The price of rice husk is fluctuated from 250 VND to 600 VND/ kg depending on different locations and timing of the year. The average price is 400 VND/ kg.

In An Giang: Unlike the Red River delta, the farm size of An Giang is larger (1.42 hectares/ farm household). This area is mainly used for paddy rice (92.11%). In addition, people grow other crops such as corn, fruits and vegetables on 0.27%, 0.33% and 7.28% respectively of this area.

With an average rice yield of 7.14 tons/ hectare/ crop season, farmers in An Giang can get about 11 tons of productivity/ crop season, equivalent to 22 tons/ year. The respective husk obtained is 4.4 tons/ year/ household. Almost rice product is sold to milling bases or rice traders; therefore, rice husk is left at the milling bases too.

Survey of millers showed almost 100% of the husk obtained in their bases is sold to dealers or directly to the consumer to produce husk briquettes for fuel, rice drying, for brick or even cement production. Prices of rice husk may vary by season or by sailing mode (wholesale or retail) and fluctuate between 500 VND and 1000 VND/ kg. The average price is 750 VND/ kg.

Of the 63 households surveyed, only 18 farmers (occupied by 28.12%)retained partly husk after milling, occupied by 25% total husk whereas 100% responsed that they left 100% or partly husk at milling base. Husk retained farmers used husk for 3 purposes:

- ❖ Burning to produce ashes to tender the field: 2/ 18 households (11.11%), accounting for 2.98% total husk
- ❖ Cooking: 15/18 households (83.33%), accounting for 20.83% total husk
- ❖ Bio-carpet: 1/18 households (5.56%), accounting for 1.19% total husk (Table 1b and Chart 6).

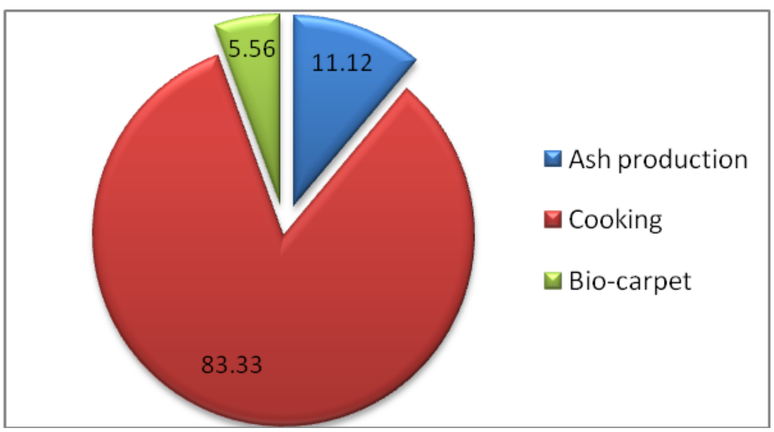

Chart 6: % farmer used husk retainedby farmers for various purposes in An Giang

It was responded from millier that about 75% husk left at their milling bases and 100% was sold, of that total 15.62% of was used for daily cooking, mainly for animal food (pig and fish), 84.38% was used as fuel for drying grain and brick production (Table 1b; and chart 7). About 43.75% are farmers who bough husk for daily cooking and 56.25% are brick producers or rice dryers. Millers could not distinguish these two users because sometime they sold husk through retailer, but they ensured total husk contributed by retailer is for big such demand as brick production or rice drying.

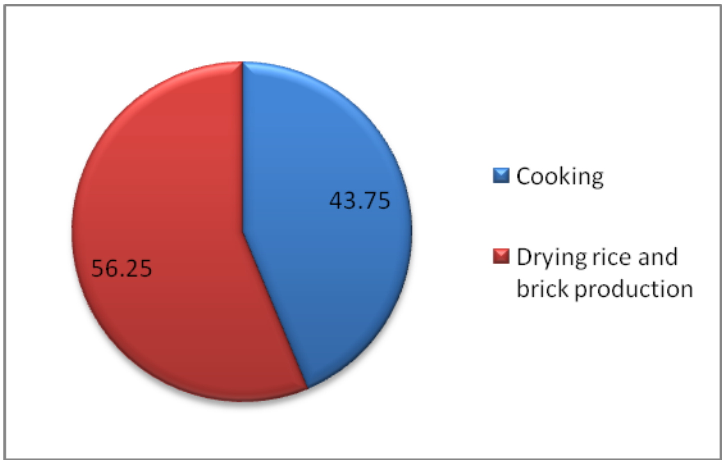

Chart 7: % farmers use husk retained by mliiers for various purposes in An Giang

The average price of husk ranges from 500 VND to 1000 VND / kg, depending on the seasons

In summing up, 58.78% husk produced in Hanoi was used for ash production and direct using to cover land; 10.10% for bio-carpet; 12.50% for cooking and 18.64% for composting. In An Giang, 2.98% husk was used for ash production, 1.19% for bio-carpet; 32.55% for cooking and 63.28% for brick production and rice drying (table 1b, chart 8 and 9)

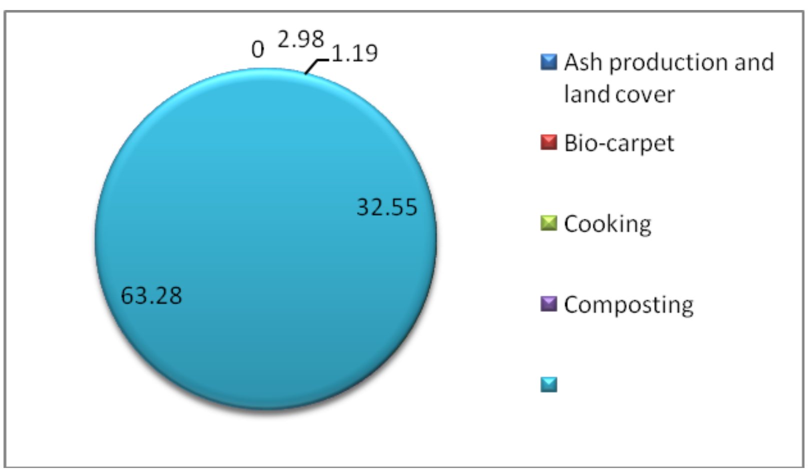

Chart 8. % total husk used for various purpose in Hanoi

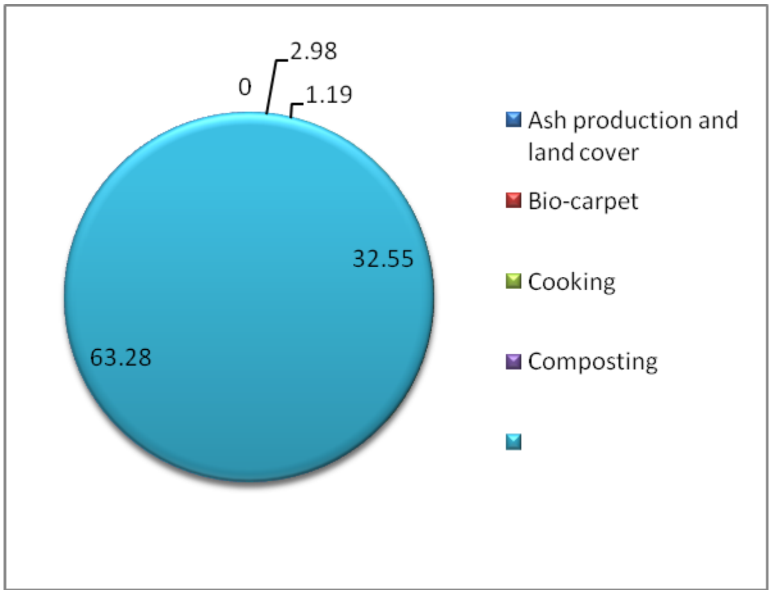

Chart 9. % total husk used for various purpose in An Giang

In summary, consumers used husks either directly or indirectly, or both for the 7 following purposes:

3.2.1. For fuel purpose

In An Giang: the survey findings showed that only 15.62% of husk sold through milling bases is used for daily cooking of farmer. Farmers can burn rice husk directly in traditional stoves by compressing it into bars or burn in improved stoves. Households mainly use husk to cook animal food (pig and fish).

As mentioned above, most of husk is used for daily cooking at household or as fuel for brick production, rice drier or even cement kilns. According to rice millers, there exists a great demand for husk while the amount of paddy purchased may vary in different seasons in the year. They are, therefore, unable to enter contracts for husk consumption. Currently, there is a great demand for husk for use as fuel in rice driers, brick and even cement production. Unfortunately, the volume of husk purchased is unstable due to the scattered sources of paddy to be purchased. According to Nguyen Thi Nguyet, a kiln owner in Residential Quarter 9, Binh Tan Hamlet, Binh My Commune, Chau Phu district, An Giang, husk is most commonly used rather than coal for the production of bricks thanks to its lower prices. The price of husk is decisive to their business performance.

Thus, if husk is bought at lower prices (in the main season: 500-600VND/kg, they can generate a profit of 6 million VND. At 800-1000/ kg, they suffer a loss of 4-6 million

VND. However, as compared with coal (22 million VND is spent on coal for one brick kiln), using husk is cheaper. At 750 VND/ kg of husk, it costs them only 18 million VND. Therefore, without husk, brick manufacturing will come to an end. Therefore, for every 1 kg of husk, the husk user gains an added income of 167 VND/ kg husk as compared to coal.

In Hanoi: among 88.47% of the farmers who retrieve husk after milling, only 11.67% use husk for cooking, accounting 10.53% of rice husk for this purpose. The proportion of farmer buying husk from milling bases for cooking was also 6.56%.

3.2.2. Utilization of ashes after rice husk using or directly produced from husk for fertilizing plants

In addition to the demand for husk, most vegetable farmers in the surveyed area are in need of ashes to fertilize the plants.

As mentioned above, among 88.47% of households retrieve husk after milling in Hanoi, 11.67% use it for cooking and then using ask for soil fertilizing, 41.67% use husk for producing ash purpose. Of the total husk buyer at milling base, there was up to 59.01% bought for producing ask.

The reason why Hanoi farmers burn rice husk for ashes to fertilize the soil is that they assume it is good for crops and can improve soil fertility. 24.98% of households assume that using husk ashes to fertilize plant can improve productivity and profitability; 43.34% of them assume that using husk ashes will reduce the amount of fertilizer that otherwise may be used; 58.34% assume that husk ashes used as fertilizer will improve fertility of the soil. Despite absence of correct data provided by farmers, the fact that farmers attempt to retrieve husk after milling for use as fertilizer can prove that they are awared of the benefits of rice husk for growth, productivity and profitability of crop production.

Depending on the size of crop areas in different regions, the amount of husk used may vary. In Hanoi, most farmers use husk and ashes to fertilize the soil while vegetable farmers manure the field with husk or ashes directly as fertilizer or indirectly through muck mix.

In An Giang, vegetable growers are well aware of the benefit of ashes. Most farmers say they must buy additional ashes from brick kilns or paddy drying facilities for fertilizer. 100% of vegetable farmers in Long Ha of Kien An commune, Cho Moi district must purchase additional ashes from brick kilns or paddy drying facilities to manure broccoli, onions, shallots, ginger.... According them, all vegetables agree with ashes. Ashes not only help increase productivity, reduce fertilization costs, reduce the amount of chemical fertilizer used but also shorten the harvest time. Findings from survey of brick producers and paddy dryers in the area showed that husk ashes produced from brick kilns and dryers are collected and sold to vegetable growers in the district. Some dealers even package the ashes and transport it by boat for sale in various areas such as Lai Thieu - Binh Duong. According to Kien An communal farmers, using ashes as fertilizer for some crops especially onions, shallots, vegetables... will reduce the risk of disease, make the soil porous, and boost the productivity. Thus, ashes are considered as indispensable inputs for growers.

According to shallot growers, instead of spending 5 million VND on fertilizer, farmers can spend only 1 million VND to buy 3 tons of ashes to fertilize for 1000sqm area. For better output, they may cover the soil with a 20-30cm layer of ashes (equivalent to 45 tons of ashes/ 1000sqm, costing 15 million VND) to grow vegetables without reclaiming land or add more fertilizer, yielding 100 million VND.

For brick producer, brick is major product. It is thus they can sell farmer the ash with very low price as subsidiary product. 3 ton of ashes bough from brick producer costing 1,050,000VND (from 300-400VND/kg) can replace 5,000,000 VND, creating an additional profit of 1,280,000 VND for every ton of ashes when replacing chemical fertilizer. Given the retrivability of ashes 16.66 %, to get 1 ton of ashes, 6 tons of husk must be burnt. Therefore, one kg of husk derives an added value of 213 VND by utilization of ash for vegetable production after subtracting cost for ashes. However, if farmers can not utilize ash from brick producer, they must produce directly from husk. The cost should be about 2,400VND for the Hanoi and 4,500VND for An Giang. It is clear that the utilization of ash can bring farmers real benefit when husk is in cooperated with main purpose (meaning using husk as fuel for brick production or for drying rice).

Analysis from Laboratory of IAE indicated that burning 1ton of husk can provide 0.3 ton of biochar. If farmers can produce biochar themselves with improved conventional inearobic techniques(without equipment), the cost for biochar will be reduced significantly (1,330 VND from Hanoi and 2,500VND for An Giang). Whereas % total Carbon from husk ash is much lower than Bio-char produced from improved conventional inearobic (91.3g/kg compared to 256.3g/kg), the content of major nutria such as P and K was also much lower (0.106% and 0.157% compared to 0.28% and 0.58%) while the content of N is the a little bit higher (0.065% compared to 0.052%) – Table 2. Whereas the ratio of ash returned from husk burning is 16.66%, lower than returning of Biochar (30%). Hence, if farmers used about 1.5 ton biochar (haft quantity compared to husk ash) for substitution of husk ash, they can save about 5000,000 for fertilizer. In case they can produce biochar for their need by simple improvement, the cost for 1.5 tons biochar (equivalent with 4.5 tons husk) is only 1,800,000VND (4,500kg x 400VND) for Hanoi farmers or 3,250,000VND (4,500kg x 750VND) for An Giang farmers whereas the amount biochar can replace 5,000,000VND for fertilizer.

As mentioned above, the high proportion of farmers in Hanoi used husk for producing ash directly (59.01 and 41.67%) was a prove of ash benefit whereas they did not have opportunity to buy husk from brick producer with lower price liked An Giang. Unfortunately, both farmers in Hanoi and An Giang have not been known or awared of biochar property. If they are awared, at least the quantity of husk used to be utilized for producing ash will be converted to biochar production.

Table 2. Biochar quality through different burning methods

No	Material and biochar	Ratio of biochar returned (%)	TC (g/kg)	OC (g/kg)	N%	P%	K%
1	Rice husk	-	228.20	36.67	0.170	1.16	0.43
2	Bio- char from conventional inearobic charring of rice husk	25.00	256.3	10.33	0.052	0.28	0.58
3	Bio-char from improved conventional inearobic charring of rice husk with chimney	33.00	335.90	8.22	0.015	0.33	0.77
4	Bio-char from inearobic charring of rice husk through indirect pyrolysis	35.00	340.5	16.33	0.072	0.39	0.78
5	Ash from freely burned rice husk in aerobic condition	16.66	91.3		0.065	0.1065	0.1572

Source: Tran Viet Cuong, Mai Van Trinh, IAE, 2012

Not only used as fertilizer, husk and ashes are mixed with soil in different ratios (typically 5 unit of ashes/ 1 unit of soil) to create a mixture used for germinating seeds.

3.2.3. Use of rice husk for composting

Although rice husk is a valuable organic material, due to changes in the farming system and practices in using manure, fewer farmers use rice husk as bio-carpet or composting. Survey findings show that only 14.86% of farmers in Hanoi compost husk and manure (pork and chicken dung). No households use husk as the only material for composting. Meanwhile, due to the existing concentrated herding system in which animal dung is not used, An Giang farmers do not use a rice husk for composting.

3.2.4. Using for bio-carpet

In the Red River Delta, many farmers use rice husk for bio-carpet. After cleaning the stall, the mix of rice husk and animal dung is collected to manure the field. In Hanoi, rice husk and chicken manure is an indispensable raw material for many of the vegetables growing areas, especially for leafy vegetables (especially in rainy season). However, at present, small husbandry farm can use other materials such as sawdust. Rice husk used for this purpose is markedly reduced. According to the survey, only 8.33% of small farmers retrieved husk from milling bases used rice husk as bio-carpet with the total amount of 3.25% husk quantity. However, for big and medium husbandry farm, farmers used husk as bio-carper more often. Most of husk used for this purpose was bough from milling base, that is why there was up to 34.43% husbandry farmer was regular custom of milling bases for husk.

Meanwhile, in An Giang only 5.56% households use husk retrieved for this purpose. Just as husk is used for composting, husk as bio-carpet is a good and environment-friendly solution. However, so far no studies have been conducted to calculate the economic efficiency of this solution.

3.2.5. Husk used for covering the field

Husk is a dry and dehydrating material that can retain moisture and soil porosity. It is, therefore, used by vegetable farmers to cover the field as a carpet layer before planting. For many vegetable growing areas, this is an indispensable condition, especially for off-season leafy vegetable crops or plant nurseries. Therefore, there still exist 16.94% of farming households who retrieved husk after milling to cover the field, consuming 6.6% of rice husk in Hanoi. Meanwhile in An Giang, farmers do not use rice husk for this purpose. So far no studies have been conducted to calculate the economic efficiency of this solution.

3.2.6. Production of fumigated husk

Fumigated husk is mixed with peat and other materials to produce soil for seedling. Fumigated husk makes up approximately 20% of the soil. Production of fumigated husk is similar to biochar production. However, unlike biochar which is burnt, husk is heated only.

To produce 20 kg of fumigated husk, 2 kg of dry wood and 60 kg of husk are needed. Depreciation on kiln and labor costs are similar to biochar production, plus the cost of firewood of around 50 VND/ kg of husk. Thus 1 kg of husk costs about 3,520 VND. Meanwhile, the sale price ranges from 4,000 VND to 6,000 VND with average price of 5,000 VND, let alone added values derived from the application of fumigated husk and reduced greenhouse gas emissions as compared to raw husk burning.

However, due the limitations of the current research, especially to effective findings or calculating the cost of fumigated husk for planting, especially seedlings and planting high value vegetables and flowers.

3.2.7. Use of husk in biochar production

According to the survey findings obtained from the Institute of Agricultural Environment, Institute of Agrochemical Pedology, and the Institute of Agricultural Science of South Central Coast, biochar yields high nutritional value to plants and improve the soil. Therefore, it can raise productivity and partly replace chemical fertilizers. Unfortunately, most people are not known of using rice husk and other byproducts to produce biochar although Section 2.2.2 shows that farmers using ashes can have significant effects on plants.

In fact, Vietnamese farmers have been known of conventional inearobic burning (by stacking the husk burning, like biochar production). However, they are not aware of the advantages of improved nutrition when husk is used this way as compared to direct burning. They, therefore, do not sustain this method. On the other hand, due to the absence of burning devices, farmers dumped husk into stacks and burn, resulting in low fuel efficiency.

Research findings by the Institute for Agriculture Environment (IAE) show that traditional biochar production can be improved by installing with a simple chimney in the middle of the husk stack to increase the combustion, resulting in markedly increased total carbon content (TC) and little reduction of organic carbon content (OC). Other criteria are equivalent to or higher than that in the traditional method. In particular, indirect pyrolysis (similar to fumigated husk production) has markedly enhanced the quality of biochar. As compared with the quality of ashes retrieved from brick kilns or direct burning, the carbon content of biochar can be 4 times higher and other nutria such as %K and %P can be double (Table 2).

Research conducted on rice by Mai Van Trinh (IAE) showed that the use of biochar on exhausted soil in Soc Son in 4 consecutive crops can help increase the yields of the 2nd and 3rd crops significantly but average yield of the 4 crops is improved little. By combining 1.5 tons of biochar (made from husk) with chemical fertilizer of 90N + + 60K2O 90P2O5 to fertilize 1 ha, the average yield is equal to that in the case where only chemical fertilizers are used. By combining 3 tons of biochar with the same amount of chemical fertilizers, the yield of spring paddy rises from 6.33 to 6.44 tons / ha (table 3).

Similarly, experiments by Nguyen Cong Vinh and collaborators from institute for Soil and Fertilizer Research Institute, University of New South Wales - Australia; Science University - Thai Nguyen University and Cornell University - America conducted in Thanh Hoa showed that the yield decreases from 7.02 tons / ha to 5.09 tons / ha when using 2.5 tons bio-char without chemical fertilizer. However, by combining 0.5 and 2.5 tons of biochar with the same amount of chemical fertilizers (90N + 26.2P2O5 + 49.8 K2O/ ha), the yield increases from 7.02 tons to 7.5 tons and 8.14 tons/ ha respectively (table 3).

Experiments conducted in the Mekong Delta (Long An) by Tran Viet Cuong (IAE) also showed that the combination of 8 tons of biochar with 90N + 60P2O + 70K2O can yield 4.2 tons/ ha, higher than the output by adopting the formula 120N + $60P_2O$ + $70K_2O$ (3.8 tons / ha).

The experiments on corn also provided similar findings. By adding 4 tons and 8 tons of biochar, the amount of nitrogen can decrease from 120kgN / ha to 90 kg while corn yields increases from 3.9 tons to 4.1 tons and 4.3 tons / ha respectively (table 3).

Table 3. Effect of biochar application on rice yield and economic effectiveness

Treatment	Cost for fertilizer (Thous. VND)	Crop yield (ton)	Price (VND)	Income (Mill. VND)	Difference of cost and income (Mill. VND)
Experiment on rice in Soc Son, Hanoi spring rice 2010-2013 (*); Thanh Hoa					

spring rice 2013 (**), and Long An summer rice 2011 (***)					
No fertilizer		5.2*	5,500	28.600	28.600,0
90N + $90P_2O_5$ + $60K_2O$	5,020,5	6.33*	5,500	34.815	29.794,5
1,5 tons biochar + 90N + $90P_2O_5$ + $60K_2O$	10,225,5	6.33*	5,500	34.815	24.589,5
3,0 tons biochar + 90N + $90P_2O_5$ + $60K_2O$	15,430,5	6.46*	5,500	35.530	20.099,5
90N + $26.2P_2O_5$ + $49.8K_2O$	3,616.9	7.02**	5,500	38.610	34.993,1
2.5 tons biochar	8,675	5.09**	5,500	27.995	19.320,0
0.5 tons biochar +90N + $26.2P_2O_5$ + $49.8K_2O$	5,351.9	7.5**	5,500	41.250	35.898,1
2.5 tons biochar +90N + $26.2P_2O_5$ + $49.8K_2O$	12,291.9	8.14**	5,500	44.770	32.478,1
No fertilizer		2.2***	5,500	12.100	12.100,0
120N + $60P_2O_5$ + $70K_2O$	5,365.7	3.9***	5,500	21.450	16.084,3
4 tons Biochar + 90N + $60P_2O$+$70K_2O$	18,541.4	3.8***	5,500	20.900	2.358,6
8 tons Biochar + 90N + $60P_2O$ + $70K_2O$	32,421.4	4.2***	5,500	23.100	- 9.321,4
Experiment on corn, Long An 2011					
No fertilizer		2.4***	4,800	11,520	11,520.0
120N + $60P_2O_5$ + $70K_2O$	5,365.7	4.9***	4,800	23,520	18,154.3
4 tons biochar + 90N	18.,41.4	5.1***	4,800	24,480	5,938.6

+ $60P_2O$+$70K_2O$					
8 tons Biochar + 90N + $60P_2O$ + $70K_2O$	32,780.5	5.3***	4,800	25.440	- 7.340,5

Source: * Mai Văn Trịnh et al.; IAE, 2013

***** Nguyen Cong Vinh, et a; NISF, 2013***

****** Tran Viet Cuong; IAE, 2012***

Unfortunately, those experiments were designed in large scale, no statistical analysis for the significant different. The yield improvement from bio-char application treatments may varied due to the soil quality of experiment locations.

In addition to increased productivity, the Energy Policy 41 (2012) paper come up with a carbon abatement value of 6$ to 10$ tone rice husk depending on whether bioenergy is generated as well that displaces fossil fuel.

Despite all that benefit, due to high cost of biochar to increase the yield of rice and corn, the revenues from carbon credits is not enough to compensate for the cost of biochar production, therefore, the exclusive use of Biochar to substitution of a proportion of fertilizers or combined used of Biochar with chemical fertilizers generate lower benefits than conventional use of chemical fertilizers or untreated control (no fertilizer) – table 3. This table also indicated that biochar application can bring farmer real benefit only when reducing production cost by improved conventional technique without low equipment input and labor cost.

Other Bio-char production technology by charring inearobic through indirect pyrolysis also developed by IAE. However, the char quality is not much improved (table 2) whereas more facilities required for production.

Below are describe of various techniques of char production

(i) Improved conventional inearobic with chimney

This is improved from conventional techniques by adding a chimney in the middle of husk load. Chimney is made of iron, size is depended on the size of the husk load. For charring 10kg of husk in a cycle, the chimney is about 10cm in diameter and 1m high. On the surface of chimney, there are a certain hole made for ventilation (Figure 1). Pouring a small volume of husk on the load and burning until flammable, then putting the chimney in the middle. Continuing supply husk until enough of estimated amount. Maintain the charring in 3hours until getting the black color of top husk. Releasing char from the load to prevent continuous flame.

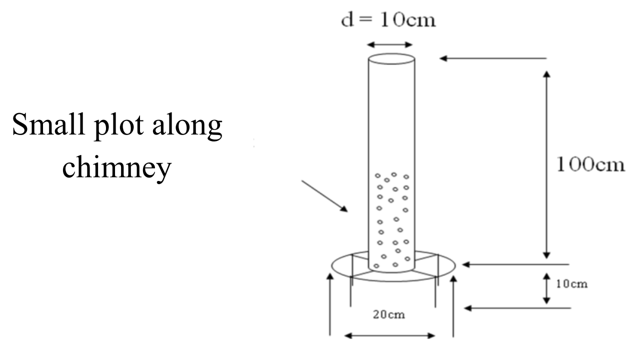

Figure 1. Biochar production through chimney

Source: Designed by IAE group

Figure 2. Rice husk burning to produce biochar through chimney

***(ii) Bio-char from inearobic charring of rice husk through indirect pyrolysis* (fumigated husk)**

Using the oven made of high temperature tolerant brick with proof and corrugated boxes. Husk is fully poured into the boxes, then put the boxes in the oven. The size of oven and box depended on the volumetric of husk for one production cycle. For production of biochar from 60kg of husk, it required 6 boxes with 40 cm in diameter, 60cm high and 1 oven with 120cm in diameter and 180cm high. Optimal time for charring is about 3,5 hours.

In fact, this technology is similar with production of fumigated husk. It is though that even the quality of biochar produced by this techniques is improved a little bit compared to improved conventional technique (Figure 3), the cost for oven and boxes is realy high.

Figure 3*: Production ofBio-char from inearobic charring of rice husk through indirect pyrolysis* (fumigated husk)

3.3. Strengths and shortcomings in the research and application of rice husk

As compared to previous years, the use of husk in production and people's daily life has made positive progress. A greater amount of husk has been utilized to serve economic development and improve people's living conditions. Husk has become a valuable source of byproducts to generate considerable income and a valuable supply for sustainable agricultural development in Vietnam.

The most notable success is the diversification of husk uses, especially the use of husk for fuel in replacement of fossil fuel (coal); the use of ashes and husk to produce ashes to manure the rice and vegetables; the use of husk to produce fumigated husk (akin to biochar), substrate for seedling propagation and planting high-value flowers.

In addition, several research institutes have got involved in the study of husk uses to maximize the efficiency in both economic and environmental aspects, especially use of husk to produce briquette in replacement of honeycomb coal (produced from coal) to meet cooking need of the people, use of husk to produce biochar, improvement of biochar production to acquire the best quality, improvement of biochar use to manure crops in replacement of chemical fertilizers to boost productivity and improve soil fertility.

However, apart from above strengths, the research and use of husk faces certain shortcomings that affect the effective use and scale-up of effective models in production, especially the use of husk on household scale in northern rural areas and for fuel in Mekong River Delta.

Firstly, research is only focused on technical and environmental assessment without proper concern about economic effects, resulting in the failure to invent a solution of high economic efficiency. Specifically, most research works are focused on the use of biochar on rice without proper concern about other high value plants such as vegetables and flowers that yield high economic efficiency. In some northern areas, farmers use fumigated husk to produce substrate for seedling propagation.

Secondly, the use of husk and husk derivatives (ashes, biochar) have not been integrated into environment-friendly rice production such as SRI, 3 increases – 3 decreases for a comprehensive assessment of husk uses in social, economic and environmental terms as well as a complete assessment of the value changes in rice cultivation in a more environment-friendly manner.

Thirdly, farmers' information sharing, awareness and knowledge are still limited. Therefore, most of them utilize husk in traditional ways without access to technological advancement, particularly biochar production, to improve crop nutrition. In concentrated production areas such as Mekong River Delta, there exist conflicting needs for husk to use for crop cultivation and as fuel. However, if the economic and environmental effects have been fully evaluated, the use of husk can be converted for other purposes, especially when farmers' awareness and benifit is improved and emission credit is charged to them.

- ❖ Brick producers will welcome new solutions if they are awared with new jobs with higher income. For example, their brick kilns may be rotationally utilized for production of biochar or fumigated husk during free production of brick.
- ❖ Rice growers should be made well aware of the added values of the use of husk as well as environment-friendly husk derivatives (biochar, ashes) to improve economic efficiency, especially the use of biochar in environment-friendly rice cultivation (SRI, 3 increase – 3 decreases); application of biochar in rice crop and crop rotation on rice base system with aims to improve the physical and chemical properties of soil, improve soil use and raise people's incomes.
- ❖ Vegetable growers will welcome biochar in replacement of ashes to improve the productivity and partly substitution of chemical fertilizers, enabling the implementation of safe vegetable production in accordance with VietGAP

standards, helping to generate more incomes for safe vegetable growers. Though the nutria of husk ashes is significantly reduced compared to husk biochar, the ratio of char applied is haft of ash (because the return of char is 300kg char/ 1000kg husk whereas the return of ash is 166kg ash/ 1000kg husk). It is thus farmers need to demonstrate 2 application methods to meet both economic and environment effect.

❖ In the Northern provinces where husk is used mainly at farming households for crop production, it is quite feasible to apply technological advancement such as biochar to improve the use efficiency, especially for high-value plants such as vegetables and flowers. This model can be scaled-up. Biochar use on rotated crops in rice base system should be promoted.

Fourthly, models of biochar production and utilization in research works are set up on a small scale at high cost without full assessment of socio-economic effects.

Finally, for sustainable exploitation and utilization of husk, research and application should not be limited to biochar production and utilization on rice but be made for various purposes.

PART 4. RECOMMENDED PILOT INVESTMENT

4.1. Recommended pilots – Objectives, outputs, activities & method and indicator for evaluation

Corresponding to TOR and as above analysing from survey, it would be feasible to propose 3below pilots:

❖ Application of improved conventional non-combustion technology to produce biochar at farm house hold and centralized scale.
  - This pilot will be undertaken with 10 demonstrations of farm level production in Hanoi and 3 demonstration of centralized scale in An Giang by utilization of brick ovens.

❖ Application of biochar for rotational cultivation of rice and vegetable in environment friendly production of rice base system.
  - The pilot will be done with 6 demonstrations (3 in Hanoi and 3 in An Giang) at the scale of 1000m2/ demonstration in 2 continuous seasons.

❖ Application of biochar as substraite for seedling vegetable production

- The pilot will be set up at Hanoi and An Giang. Each province consist of 1 demonstration site to produce 100,000 seedlings/ crop season in 2 seasons of the year.

Pilot 1: Application of improved conventional non-combustiontechnology to produce biochar at farm house hold and centralized scale.

❖ **Objectives**

- To enhance awereness and capacity of farmers in Hanoi and brick producers in An Giang to help them approaching to new application of rice husk, hence creating more job, changing of rice husk use toward friendly environment from reduction of GHG emission, boosting the rice husk value to improve farmers' benefit.
- To assist farmers developing market for biochar

❖ **Outputs**

- 10 demonstrations of biochar production at farm house hold in Hanoi with capacity of 500kg husk/ crop season in 2 seasons;
- 02 demonstration of biochar production at capacity of 10tons husk/ cycle and one demonstration for brick and ash production (as control) at capacity of 24 tons husk/ brick production cycle in An Giang;
- 2 on field workshopsin 2 pilot areas with 25 participants/ workshop

❖ **Activities and conducting method**

No	Activity	Conducting method
1	Selection of beneficiaries	- 10 representatives of average and poor farmers with priority to women from at least 2 districts of Hanoi; - 3 brick producers with suitable size of oven to produce biochar (from 10 tons husk/ oven/ cycle) from An Giang
2	Pilot design	* In Hanoi: - 6 farmers among 10 beneficiaries for conducting the demonstrations of biochar production as improved conventional inearobic technology with chimney;

		- 2 farmers apply conventional technique; - 2 others for ash production (means free combustion) as control. * In An Giang: - 2 among 3 brick producers will apply improved conventional inearobic techniques with modification of adding the chimney in the middle of oven to produce biochar. The Chimney is roundish shape, 30cm in diameter, equal high with oven, made of steel or iron, making holes on the surface for ventilation. - 1 producer will maintain brick production as control.
3	Guiding farmer to undertake pilot	* In Hanoi: - For biochar production: apply improved conventional inearobic techniques as described in part 3.2.7. - For ash production: maintain as farmer practice by free combusting in aerobic condition * In An Giang: - For biochar production: Firstly pouring about 200kg of husk into the oven and burning. When flammable, add more husk into the oven until being full (about 10tons husk/ oven/ cycle), then close the gate with steel coverer, covering the top of oven with mud to prevent flowing of oxygen into the inside. Maintain the oven in inearobic condition until the husk on the top get black color

		(estimated in 2 days). - For brick production: maintain the same procedure as farmer practice. Husk will be supply continuously through oven gate. It is estimated that about 24 tons of husk will be needed for one cycle of brick production with capacity of 120,000 bricks.
4	Assisting biochar producer developing market for biochar by linkage of biochar producers and users	Assist farmer to design container and introduce biochar in fertilizer agency
5	Organizing 2 on field workshop in Hanoi and An Giang	Workshops organized with the participation of 25 local leaders and farmers within demonstration site and surrounding areas (for each workshop) to visit pilot site and discuss on how to scale up the production and utilization of Biochar

❖ **Indicator for result eveluation**

- Biochar and ash quality: evaluate by analyzing % TOC, % OC, CEC (cmolc/ kg); % total N; % P2O5; %K2O; SiO¬2, moisture; pH from husk and char;
- GHG emission: Calculating CO2 emitted by adjusting from %C in husk and %C remain in char and ash, then converting % C reduction to CO2 emitted with the ratio of 44/12 (method of analyzing will be referred in part 4.4.1);
- Production cost, income and net benefit.

Method of analyzing will be referred in part 4.4.1.

Pilot 2: Application of biochar for rotational cultivation of rice and vegetable in environment friendly production of rice base system.

❖ **Objectives**

- To raise awareness and capacity in biochar application of rice based producers;
- To integrate the use of biochar for both rice and vegetable rotationally cultivating in rice base system to maximize the use of fertility, to improve soil physical and chemical, to increase land use index, hence bring farmers more benefit;
- To integrate the use of biochar in climate friendly rice production such as SRI, 3 reductions - 3 gains to reduce cost of irrigation, seed, chemical fertilizers and pesticides, then to increase benefit of farmers;
- To substitute ash using with biochar for better environment from reduction of GHG emission.

❖ **Outputs**

- 6 demonstrations (3 in Hanoi and 3 in An Giang) for vegetable – rice rotationally cultivation followed the protocol of SRI (in Hanoi) and 3 reductions - 3 gains (in An Giang) at the scale of 1000m2/ demonstration in 2 continuous seasons;
- 2 on field workshops in 2 demonstration areas with 50 participants/ workshop

No	Activity	Conducting method
1	Selecting beneficiaries	- Selecting 6 suitable farm households (3 from Hanoi and 3 from An Giang) with average economic capacity; use to be familiar with rotational planting rice and vegetable and SRI/ 3 reductions - 3 gains techniques; Suitable land size (1000sqm), from at least 2 districts of each province. In case farm size is smaller than 1000sqm, added farm may be selected but nearby the main farm Priority is given to women.
2	Designing pilot sites	In each province, 2 sites will be followed SRI/ 3 reductions - 3 gains and one site will not applied (as control). In Hanoi, the rotation mode will be spring rice + summer – autumn vegetable. In An Giang, vegetable will be planted in dry season, rice may be applied before or post vegetable
3	Conducting pilot implementation	At all pilot sites, demonstration will perform 7 treatments: (i). Using of chemical fertilizer only (farmer practice with suitable dose for rice and vegetable)*

		(ii). Using 100% biochar (3,000kg/ ha**); (iii). Using 100% ash (1,500kg/ ha***); (iv). Using 25% biochar (750kg) + 75% chemical fertilizers; (v). 50% biochar (1,500kg + 50% chemical fertilizers); (vi). 25% ashes (475kg) + 75% chemical fertilizers; (vii). 50% ashes (750kg) + 50% chemical fertilizers. All above treatments will be designed with 3 replications, plot size is approximately 50sqm.
4	Monitoring quality of vegetable	Taking sample of vegetable before harvesting for quality analyzing
5	Assisting farmer to access market for safe vegetable	Assist farmers to design container and introduce safe vegetable in market
6	Organizing 2 on field workshop in Hanoi and An Giang	Workshops organized with the participation of 50 local leaders and farmers within demonstration site and surrounding areas (for each workshop) to visit pilot site and discuss on how to scale up the application of Biochar

Note:

*: Chemical fertilizer applied for rice: using 90N + 30P2O5 + 50K2O as guilded of SRI and 3 reductions – 3 gains; for vegetable: applied the dosage of 60N + 120P2O5 + 90K2O

** Biochar is assumed to use for substitution of organic matter. The dosage of organic matter advised for using on rice and vegetable is 10tons/ ha and the ratio of biochar returned from husk is 30%, the dosage is of biochar used should be approximately 3,000kg/ ha.

*** The ratio of ash retuned from husk burning is 16.66% whereas the ratio for biochar is 30%. To keep the equal cost of biochar and ash for comparison and selection of higher bio and economic efficacy, the dose of ash should be equal ½ of biochar (means 1,500kg/ha).

❖ **Indicators for result evaluation**

- Growing criteria of rice and vegetable: measuring at harvesting stage;
- Crop yield;
- Level of chemical pesticides use;
- Vegetable quality: analyzing with GC and HPLC the residue of Nitrate, pesticide and harmful micro-organisms;
- Production cost, income and benefit;
- Soil quality after two crop season: taking soil sample before and after 2 crop seasons and analyzing dynamic of: pHKCl; OC; N% (total N); P2O5 %; K2O%; CEC (cmolc/ kg); SiO2% with appropriate analysis.

Method of observation and analyzing will be referred in part 4.4.1

<u>Pilot 3</u>: Application of biochar as substraite for seedling vegetable production

❖ **Objectives**

- To enhance farmer capacity in application of biochar for seedling production aiming to stimulate growing and responding to unfavorable condition (cold, shower);
- To substitute fumigated husk with biochar produced by improved conventional inearobic technique for lower cost.

❖ **Output**

- 1 demonstration site in Hanoi and 1 in An Giang to produce 100,000 seedlings/ crop season/ site in 2 seasons of the year.
- 2 on field workshops in 2 demonstration areas with 25 participants/ workshop

❖ **Activities and conducting method**

- Selecting beneficiaries: Selecting each farmer from Hanoi and An Giang who had long experience in seeding production, priority for women;
- Conducting demonstration: implementing in 2 continuous seasons. Seedlings are prepared in both tray and land area. Each demonstration includes 2 treatment:
  (i). Use of farmer's substrate (or farmer's practice);
  (ii). Use of biochar (20%) + other substrate as farmer practice;
  (iii). Use of biochar (50%) + other substrate as farmer practice
  (iv). Use of fumigated husk (20%) + other substrate as farmer practice;
  (v). Use of fumigated husk (50%) + other substrate as farmer practice
  All treatments will be designed with 3 replicates. Chemical fertilizer will be used as farmer practice.

- Organizing 2 on field workshop in Hanoi and An Giang for 25 peoples of each workshop.

❖ **Indicators for result evaluation**

- Germination ability of seed;
- Level of seedling resistance to unfavorable condition;
- Seeding growth;
- Potential recycle of substraite;
- Cost and benefit

Method of observation will be referred in part 4.4.1.

4.2. Work plan and implementation arrangements

4.2.1 Work plan:The pilots will be undertaken in 15 months, starting from Janury 2014 with the participation of various stakeholders. The detail work plan including activities, venue, timeframe, expected outputs and facility required will be referred in Table 4 and summary of work schedule will be presented in Table 5.

4.2.2. Implementing arrangement: The arrangement including activities, location, implementing agencies and partners will be refered in Table 6.

Table 4. WORK PLAN

#	Activities	Place/ venue	Staff labor (working days) required	Commencing – finishing date	Expected outputs	Facility required
1	Field survey for selection of beneficiary and suitable sites	Hanoi & An Giang	10 (1 per. x 5 days/ region x 2 regions)	15-25 Jan. 2014	❖ 21 beneficiaries and sites selection selected ❖ Farmers requirement and proposals	❖ Round air tickets from Hanoi – Can Tho/ HCM ❖ Car for inland transport to serve survey; ❖ Hotel ❖ Labor
2	Design detail plan for demonstration	Hanoi	2 (1 per. x 2 days)	26-30 Jan. 2014	❖ Detail plant and revised protocol	❖ Labor
3	Signing the contract with beneficiaries (if necessary)	Hanoi & An Giang	2 (1 per. x 2 days)	5-10 Feb.2014	❖ Contract signed	❖ Labor
4	Material preparation	Hanoi & An Giang	5 (1 per. x 5 days)	15-25 Feb. 2014	❖ All materials prepared	❖ Labor
5	Undertaking pilot 1	Dong Anh and My Duc, Hanoi	5 (1 per. x 5 days)	March & July 2014	❖ Pilot Set up ❖ Evaluation	❖ Round air tickets from Hanoi – Can

		Cho Moi and Phu Chau, An Giang	5 (1 per. x 5 days)	May & Sep.2014	(observation, measuring, sampling &analyzing)	Tho/ HCM ❖ Car for inland transport to serve survey; ❖ Hotel ❖ supporting farmers: seed; fertilizer including biochar; pesticides; ❖ Labor for evaluation; ❖ Cost for analyzing soil and vegetable quality; measuring GHG emission; ❖ Material for marketing biochar and safe vegetable: bag, label…
6	Undertaking pilot 2	Dong Anh and My Duc, Hanoi	20 (2 per./ x 5 days/ season x 2 seasons)	Mar. – Oct. 2014		
		Cho Moi and Phu Chau, An Giang	20 (2 per./ x 5 days/ season x 2 seasons)	June 2014-Feb. 2015		
7	Undertaking pilot 3	Dong Anh and My Duc, Hanoi	4 (1 per./ x 2 days/ season x 2 seasons)	Sep. – Oct. 2014 & Jan – Feb. 2015		
		Cho Moi and Phu Chau, An Giang	4 (1 per./ x 2 days/ season x 2 seasons)	Aug. – Sep. 2014 & Dec.2014 – Jan. 2015		
8	Evaluation	Demonstration sites	216 (2 per./ 1 evaluation x 2 eva/	Mar.2014-Fe.2015	❖ Field records ❖ Lab records	❖ Round air tickets from Hanoi – Can Tho/ HCM

			month/sites x 6 sites x 9 months)			❖ Car for inland transport to serve survey; ❖ Hotel
9	Outsider monitoring	Hanoi and demonstration sites	-	July& Dec.2014	❖ Field visit ❖ Monitoring report	-
10	Information share	Demonstration sites	18 (3 per./ workshops/ sites x 6 sites x 1 day)	July-Sep. 2014 & Dec.-Jan. 2015	❖ 3 workshop in Hanoi, 100 participants ❖ 3 workshop in An Giang, 100 participants	❖ Round air tickets from Hanoi – Can Tho/ HCM ❖ Car for inland transport to serve survey; ❖ Hotel ❖ Meeting room ❖ Coffee, tea, stationary
11	Reporting	Hanoi	20 (1 per. x 4 days/ report x 5 reports)	Feb.; June; Sep; Dec. 2014 & Mar. 2015	❖ 2 starting reports ❖ 4 mid term reports ❖ 1 final report	❖ Stationary, photocopy

Table 5. WORK SCHEDULE

Activities	Place/ Venue	Months														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Field survey for selection of beneficiary and suitable sites	Hanoi and An Giang	■														
Design detail plan for demonstration	Hanoi		■													
Signing the contract with beneficiaries (if necessary)	Hanoi and An Giang		■													
Material preparation	Hanoi and An Giang		■													
Undertaking pilot 1	Dong Anh and My Duc, Hanoi			■				■								
	Cho Moi and Phu Chau, An Giang					■				■						
Undertaking pilot 2	Dong Anh and My Duc, Hanoi			■	■	■	■	■	■	■	■					
	Cho Moi and Phu Chau, An Giang						■	■	■	■	■	■	■	■	■	
Undertaking pilot 3	Dong Anh and My Duc, Hanoi								■	■			■	■		
	Cho Moi and Phu Chau, An Giang							■	■			■	■			
Evaluation	Demonstration sites			■	■	■	■	■	■	■	■	■	■	■	■	
Outsider monitoring	Hanoi and demonstration sites							■					■			
Information share	Demonstration sites							■	■	■			■	■		
Reporting	Hanoi		■				■			■			■			■

Table 6. IMPLEMENTING ARRANGEMENT

Activities	Place/ Venue	Implementors	Partners
Field survey for selection of beneficiary and suitable sites	Hanoi and An Giang	Implementing Agency	- Dept. of Hanoi and An Giang Agriculture and Rural Dev. (DOARD); - Sub. Dept. of relevant districts (Dong Anh, My Duc, Cho Moi, Phu Chau)
Design detail plan for demonstration	Hanoi	Implementing Agency	
Signing the contract with benificiaries (if necessary)	Hanoi and An Giang	Implementing Agency	Sub. Dept. of relevant districts (Dong Anh, My Duc, Cho Moi, Phu Chau)
Material preparation	Hanoi and An Giang	Implementing Agency; benificiaries	
Undertaking pilot 1	Dong Anh and My Duc, Hanoi	Implementing Agency; benificiaries	
	Cho Moi and Phu Chau, An Giang	Implementing Agency; benificiaries	

Undertaking pilot 2	Dong Anh and My Duc, Hanoi	Implementing Agency; benificiaries	
	Cho Moi and Phu Chau, An Giang	Implementing Agency; benificiaries	
Undertaking pilot 3	Dong Anh and My Duc, Hanoi	Implementing Agency; benificiaries	
	Cho Moi and Phu Chau, An Giang	Implementing Agency; benificiaries	
Evaluation	Demonstration sites	Implementing Agency	
Ousider monitoring	Hanoi and demonstration sites	Consulting Firm, Project; Management Board	- Dept. of Hanoi and An Giang Agriculture and Rural Dev. (DOARD); - Sub. Dept. of relevant districts
Information share	Demonstration sites	Implementing Agency	Manager and farmers from project sites and surrounding areas
Reporting	Hanoi	Implementing Agency	

4.3. Capacity building needs for all parts of the pilot

Biochar development has just received proper attention in recent years for use as cultivation waste-originated fertilizers to reduce environment pollution. The Institute of Agricultural Environment is the first to initiate pilot biochar production on household scale and develop models of biochar use to manure some agricultural crops in Hanoi, Hai Duong, Long An, Thai Binh and Nam Dinh provices.

Due to its recent emergence, biochar is applied on a small scale in pilot models. Survey findings show that less than 20% of farmers in Hanoi have been awared of biochar and none of them have applied biochar. Survey findings in An Giang produce the same findings. However, survey households are awared of biochar as a result of the pilot application of biochar in projects undertaken by the Institute of Agricultural Environment and CARE. Although few farmers are informed of or have applied biochar, they have been awared that biochar produced from abundant local sources of materials such as straw, husk, stems… not only yields positive effects to produce fertilizers but also reduces environment pollution. However, in order to develop the program of bio-char production and application, it is really need to have training program for not only farmers but also for local officer.

4.3.1. Training of farmers

Pre-project survey findings show that 100% of farmers in An Giang and 78.3% of farmers in Hanoi want to learn technology of biochar production and application in agriculture simply because it enables them to utilize organic wastes from cultivation to produce carbon sources as an alternative to organic fertilizers on some crops such as rice, vegetables and others. Collection of findings from field surveys shows the demands for capacity building by local farmers and officials as follows:

- ❖ Collection and production of biochar on household scale with improved traditional technology in order to enhance output quality (proposed by northern farmers);
- ❖ Improved biochar production with husk-fueled brick kiln to enhance output quality (proposed by southern farmers);
- ❖ Biochar production by farming households from available sources of straw to minimize straw burning to reduce environment pollution;
- ❖ Biochar use on rice to improve the quality and productivity of rice production;
- ❖ Biochar application in vegetable production to improve the productivity and to control pest and reduce chemical fertilizers;

❖ Biochar application to produce substrate for seedling propagation of high- quality vegetables…

4.3.2. Training of local officer

Up to date, almost local officer and techniciansare under shortage of knowledge related to biochar production and application. Though, it is not very high technology, they need also awared and knowledge on biochar production techniques and application. The target of training is not only local technician but also may include extension workers. They may require TOT courses on general understanding of bio-char; material selection and production technology (not only for biochar but also for other uses of byproducts); application techniques appropriate with various crops and soil types; evaluation and monitoring; extension for scaling up the application.

4.4. Monitoring and reporting

4.4.1. Monitoring

During the Pilot implementation, the monitoring and evaluation of implementing results will be undertaken through whole crop season.

Monitoring of technical and environment effects:

❖ **To the demonstrations of biochar production:**

- Evaluating the quality of biochar and ask. The evaluation will be done 1 time at 10 days after completion of production. 5 sample from each production site will be taken for analyzing % TOC, % OC, CEC (cmolc/ kg); % total N; % P2O5; %K2O; SiO¬2, moisture; pH from husk and char;
- GHG emission: Measuring CO2 emission from each demonstration. By trapping air and analyzing with GCMS;

❖ **To the demonstrations of rice and vegetable production:**

- Evaluate the plant growth criteris, elements forming the crop yield and crop yield of rice and vegetable.
  - For rice:
    Measuring the high, number of tillers at every 15 days;
    Counting the effect tiller/ plant; measuring the length of panicle; number of grain/ panicle; weight of 1000 grains and plot yield;
    The method of measuring will be followed the guide of MARD for variety evaluation
    Level of chemical pesticides use;

Production cost, income and benefit;

- Monitoring the vegetable quality: sampling (5 samples/ plot) and analyzing quality with the focus on Nitrate, pesticide residue before harvesting with GC and HPLC equipments.
- Monitoring the soil quality after 2 continuous crop season: Sampling and analyzing the soil quality after 2 seasons. Criteria of analyzing includes pHKCl; OC; N% (total N); P2O5 %; K2O%; CEC (cmolc/ kg); SiO2% with appropriate analysis. Analyzing method is referred in table 7.

❖ **To seedling production demonstratiom:**

- Counting the plant density alive at 10 days after sowing and before planting from all demonstrated plots;
- Evaluating growing speed of seedling: number of leaf/ plant, measuring the height at every 10 days and before planting;
- Evaluating time from sowing to planting;
- Remain nutria of biochar after each cycle of production and potentiality of recycling.

Table 7. Observation and determination methods

Ord.	Factors	Determination method
A. Soil		
1	pH_{KCl}	by Electrode (ratio of soil to solution = 1:2.5)
2	C total	WalKley – Black
3	N total	Kjeldahl
4	P_2O_5	Treated by H_2SO_4 + $HClO_4$ and determine by molyden colourimetry method
5	K_2O	Treated by H_2SO_4 + $HClO_4$ and determine by flame photometer
6	CEC	Amon axetat method (pH=7.0)
7	SiO_2	Treated by HNO3 and HClO4 and determine by Atomic absorption Spectrometry
B. Plant		
1	Yield	Grain weight after drying

2	Yield components	1000-grain weight, number of per panicle, and number of panicle per hill

Analysing economic effect: Caculating the production cost, income, and net benefit of all demonstration sites.

4.4.2. Reporting

During the pilot implementation, implementing agency will be required to prepare following reports:
i. Report of field survey and selection of benificiaries and location of demonstrations. The report will be completed at the end of second month from starting time and submitted to management office for comment before undertaking;
ii. Detail plan and revised protocol for each pilot site: submitted at the end of second month;
iii. Mid term report of 1st season (implementing from month 3 to 5): submitted at the second week of month 6;
iv. Mid term report of 2nd season (implementing from month 6 to 8): submitted at the second week of month 9;
v. Mid term report of 3rd season (implementing from month 9 to 11): submitted at the second week of month 12;
vi. Mid term report of 4th season (implementing from month 12 to 14): submitted at the second week of month 15;
vii. Final report: submitted at the end of month 15.

- ❖ The mid term report are required to fully discrible the achievement between 2 periods about the scale, time of implementation; evaluation of plant growth; quality of biochar and soil quality after season; ability to develop market for project outcomes; lesson learnt from demonstration; proposed revision if necessary for next season.

- ❖ **The final report will be required for full analysis of:**

    - Charateristic of pilot location (natural, economic and socil condition);
    - Objectives, contents and method of implementation;
    - Technical analysis from observation of each pilot;
    - Analysing social, economic and environment effect;
    - Evaluating feasibility and assistance requested (technique, policy, money) for scaling up the pilots;

- Experience learnt, successes and remains of pilot implementation and proposal for further research.

4.5. Summary of pilot costing and detailed costs by implementing agency:

The total cost for investment pilot is 69,960 USD (table 8), including 30,080USD for staff salary, hotel, air ticket and inland travel (table 9); 5,300USD for stationary, communication and workshop (table 10); 26,580USD for materials and analysis (table 11).

Table 8.Summary of Costs

Item	**Costs (USD)**
Total Costs of Financial Proposal	**69,960**
Cost of Staff Salary, Hotel and Traveling (Sub total 1)	30,080
Cost of Stationary, communication, workshops and Reporting (Sub total 2)	5,300
Cost of Materials and Analysis (Sub total 3)	26,580

Table 9: Breakdown of Reimbursable Expenses for Staff

Activity	Staff labor			Hotel			Air ticket			Car renting		
	Quantity (working day)	Price Unit (USD)	Total (USD)	Quantity (Night)	Price Unit (USD)	Total (USD)	Quantity (round ticket)	Price Unit (USD)	Total (USD)	Quantity (km)	Price Unit (USD)	Total (USD)
Field survey for selection of beneficiary and suitable sites in Hanoi	5	90	450	5	40	200	1	300	300	150	0.6	90
Field survey for selection of beneficiary and suitable sites in An Giang	5	90	450									
Design detail plan for demonstration	2	90	450							300	0.6	180
Signing the contract with benificiaries (if	2	90	180									

necessary)												
Material preparation	5	90	180									
Undertaking pilot 1 – Hanoi	5	90	450							150	0.6	90
Undertaking pilot 1 – An Giang	5	90	450	5	40	200	1	300	300	300	0.6	180
Undertaking pilot 2 – Hanoi	20	90	1,800							300	0.6	180
Undertaking pilot 2 – An Giang	20	90	1,800	20	40	800	4	300	1,200	600	0.6	360
Undertaking pilot 3 – Hanoi	4	90	360							300	0.6	180
Undertaking pilot 3 – An Giang	4	90	360	4	40	160	2	300	600	600	0.6	360
Evaluation in Hanoi	54	90	4,860							2,700	0.6	1,620

Evaluation in An Giang	54	90	4,860	54	40	2,160	18	300	5,400	5,400	0.6	3,240
Outsider monitoring												
Information sharing in Hanoi	3	90	270							150	0.6	90
Information sharing in An Giang	3	90	270	3	40	120	3	300	900	300	0.6	180
Reporting	20	90	1,800									
Total	211	90	18,990	91	40	3,640	29	300	8,700	11,250	10.2	6,750
Sub Total 1	**38,080**											

Table 10: Breakdown of Reimbursable Expenses for Stationary, Communication and Workshop

No	Description	Unit	Unit Cost
1	Communication		600
2	Stationary, equipment, instruments, supplies, etc.		500
3	Meeting hall, banner and computer for the workshop	Workshop	6 workshops x 300 = 1,200
4	Tea break	Man	200 participant x 5USD = 1,000
5	Meal for workshop	Man	200 participant x 10USD = 2,000
	Sub Total 2		**5,300**

Table 11: Breakdown of Reimbursable Expenses for materials and analysis

No.	Item	Quantity	Price Unit (USD)	Total (USD)
1	Seed (kg)	0.3	500	150.00
2	Nitro fertilizer (kg)	600	0.6	360.00
3	Phosphorous fertilizer (kg)	1440	0.25	360.00
4	Potasium fertilizer (kg)	540	6	3,240.00
5	Husk (ton)	49	50	2,450.00
6	Biochar (kg)	3000	0.2	600.00
7	Pesticide (kg)	4	30	120.00
8	Soil analysis (sample)	30	80	2,400.00
9	Substrate analysis (sample)	20	40	800.00
10	Vegetable analysis (sample)	30	120	3,600.00
11	Emission sampling and measure (sample)	15	500	7,500.00
12	Supporting market development			5,000.00
	Sub Total 3			**26,580.00**

4.6. Summary Poverty Reduction and Social Strategy (SPRSS) and Indigenous Peoples Development Plan

It is optimistic that the pilots of rice husk use and integration of biochar with current environmently sound practices such as SRI, 3 reductions 3 gains, safe vegetable production in rice base system will bring clear advantage of economic benefit as well as social policy by creating more job, emerging higher income for various stakeholders, hence contributing to hunger eradication, poorverty reduction and environment protection, meeting the target of social and human development in rural areas.

Above survey findings showed that rice husk is used for many purposes. In the Red River Delta, due to the small and scattered production system, the sources of husks collected are not concentrated. Rice husk is mostly used by farmers in their households. Over 80% of agricultural household retrieve husk from milling facilities for use as fuel and ash fertilizer to manure the fields, especially for the spring crop as to prevent young rice and paddy from the cold weather because of the rich contents of potassium in ashes. They may use husk to cover the fields to maintain stable humidity for vegetable seedling or growing off-season vegetables during rainy season; they may use husk as bio-carpet; they may use husk for composting or producing fumigated husk to make soil for seedling or growing plants. All above actions are aimed to improve soil porosity, moisture stability, potassium utilization and soil fertility.

In the Red River Delta, rice husk is used mainly on a household scale. The commercialization of husk has not been developed well. However, almost 100% of the husk has been utilized. A portion of husk is commercialized by milling facilities at the average price of 400 VND / kg, approximately 8% of the paddy price. An estimated amount of 1.44 million tons of husk is produced in the Red River Delta provinces a year, generating around 576 billion.

In the Red River Delta, most households who retrieve husk for use after milling are merely involved in agricultural production without any by-trades to generate further income. Survey findings show that 100% of them work in cultivation sector, mainly rice farming. 26.65% of them raise animals as an additional trade. 6.67% of them provide services as an additional trade with income ranging from 8.24 to 39.42 million VND/ household/ year and average income of 27.13 million VND. Given average size per household of 4.49 members, the average income per capita is 6,042,000đ/ year, equivalent to 503.506đ/ month. Among survey farmers, up to 78.12% of households are at moderate level of economic condition while less than 21.88% of them are wealthy or well-off. Given the average size of rice cultivation of 4.88 sao/ household, productivity of 195kg/ sao, paddy output of 952.3kg/ crop/ household equivalent to 1,.904.6kg/ year, each household will yield 381 kg of husk a year. If 80% of this volume of husk is used, an additional income of 121,000VND will be generated. 59.3% of rice growers are women.

In Mekong Delta: husk is concentrated in the milling facilities and then sold to farmers for use as fuel. A market for husk, therefore, has been formed. Almost 100% of husk has been commercialized. Husk is sold at average price of 750 VND / kg. If 4.84 million tons of husks is retrieved from milling facilities, an annual income of 3,660 billion is generated. On average, 8.73 million tons of husks are produced nationwide. At average price of 600 VND / kg, the annual income generated from husk is 5,220 billion.

As a result of feasibility study, the initial stakeholder gain benefit from rice husk is rice millers. In Mekong River Delta, income generated of rice miller from husk is marked. An average rice milling base that mills 13,000 tons of paddy/ year can get 2,585 tons of husks, equivalent to 1.936 billion VND/ year.

The next beneficiaries of rice husk are direct rice husk users. According to brick producers in An Giang, due to the fluctuation in brick prices, coal or wood used as fuel may result in high risk of losses. Therefore, husk is a good alternative that helps them with stable jobs and generates employment.

- ❖ To produce 1 batch of bricks, an estimated volume of 24,000 kg of husk is needed. Given the labor cost of 800,000d, 1 kg of husk corresponds to 333đ of wages for workers. The estimated volume of 8.37 million tons of husk produced in the country corresponds to wages worth 349,200 billion VND. Given one unit of labor worth 150.000đ, it will create 232.800 labor units.
- ❖ Using as fuel, husk seller can get revenues of 400 VND/ kg (in Hanoi) and 750 VND/ kg (in An Giang) for sale of husk. Husk can be used in replacement of other fuels such as coal and wood to yield a difference of 167 VND/ kg for husk users. In addition, brick producers can get revenues from the sale of ashes at 35 VND/ kg of husk. Moreover, vegetable growers also benefit from the use of ashes: 1 kg of husk generate 213 VND for them. Therefore, the total benefits from 1 kg of husk generated for husk owners, husk users for baking bricks and vegetable growers (ash users) in An Giang are 1,165VND.

In addition to benefit of husk user, using of husk may generate the benefit from reduction of gas emission in comparison with using fossil coal. According to the Energy Policy 41 (2012) paper, the carbon abatement value is ranged from 6$ to 10$ tone rice husk depending on whether bioenergy is generated as well that displaces fossil fuel.

The next benificiaries are asked users. In addition to direct benefits from the use of husk, husk also yields added values for users. Although there is no detailed and full analysis of the cost – benefit of using husk, initial study findings have identified that the added benefit of rice husk user and post rice husk use is significantly, contributing to generating more income, increasing investment effectiveness and developing a sustainable agriculture production.

Survey findings also indicated that if used properly, husk ashes or biochar can significantly or completely replace chemical fertilizers (for short-term leafy vegetable and herbs), meeting the requirements for safe vegetables aboutNitrate residue, whereby generating more income for vegetable growers and cutting down the cost for quality monitoring, and meeting the demand for safe vegetables, a matter of social concern.

- ❖ According to shallot growers, 3 tons of ashes costing 1 million VND used on 1 unit of area can replace an amount of fertilizer worth 5 million VND on the same area. For better output, they may cover the soil with a 20-30cm layer of ashes (equivalent to 45 tons of ashes/ unit of area, costing 15 million VND) to grow vegetables without reclaiming land or adding more fertilizer, yielding a profit of 100 million VND.
- ❖ Given the option that yields the lowest profitability, 1 ton of ashes costing 350,000 VND can replace fertilizer worth 1,660,000 VND, yielding an additional profit of 1,280,000 VND for every ton of ashes. Given the retrivability of ashes of 16,6%, to get 1 ton of ashes, 6 tons of husk must be burnt. Therefore, one kg of husk derives an added value of 213 VND from its byproduct (after subtracting cost for ashes bought from brick producers)

It can be seen from the fact that, farmers in Hanoi and An Giang have used ashes effectively to manure vegetables. However, burning husk is required to acquire ashes, resulting in negative environmental impact. Therefore, it is necessary to improve C sources effectively towards a more environment-friend way like biochar use.

The above fact was also a big lesson for biochar application. Although the production and use of biochar is little known to farmers or scaled-up, according to many research findings by Institute of Agricultural Environment, Institute of Agrochemical Pedology, Institute of Agricultural Science of South Central Coast, it generates great economic efficiency. Biochar can be used to replace organic fertilizers (an exhausting source) to reclaim the land (see results in the section Environmental Impact) and enhance Carbon stability in soil. Therefore, it can be used to replace chemical fertilizers in clean agricultural production and organic agriculture, meeting the demand for food safety. However, due to its high production costs, biochar can only generate economic efficiency if it is used towards the target of emission reduction or on high-value plants. Unfortunately, applicable research is limited to study on rice and maize, the use of biochar on which generates lower economic efficiency as compared to chemical fertilizers. Even when added value derived from reduced greenhouse gas is taken, biochar use does not appeal to farmers. It is because one ton of burnt straw/ husk emits 1.49 tons of Carbon, equivalent to 298.000đ of emission credit (or 894,000/ ton of biochar).

Three reasons may explain the low economic efficiency of above models of biochar use on rice:

- Firstly, biochar is produced in furnace at very high cost (3,470đ/kg) while the sale price is low (1,200-1,500đ / kg). According to research finding by the Institute for Agricultural Environment, the production cost may be cut down in improved inaerobic burning with chimney installed. In this method, the quality of biochar is equal to the quality of biochar produced in conventional charring, reducing the depreciation cost. On the other hand, this model can be applied to produce biochar on household scale to make full use of idle labour to reduce the production cost and freight.
- Secondly, biochar application is limited to use on rice and maize, the two plants of low economic efficiency. Therefore, the economic efficiency of biochar is not obvious due to the little increase in productivity it brings about.

  Lesson learnt from the use of ashes by Hanoi and An Giang farmers on vegetables show that the use of biochar on vegetables can yield markedly higher profits than the use on rice and maize. Biochar is not only used to replace chemical fertilizers to generate income from increased productivity but also helps to produce safe agricultural products, creating added value from safe vegetables, especially organic vegetables. Unfortunately, neither Hanoi nor An Giang farmers have been able to calculate the benefits from increased vegetable outputs thanks to the use of ashes. They are not aware of the production and use of biochar. They, therefore, have not applied biochar into vegetable production.

- Thirly, the research and application of biochar has not been integrated in other environment and economical frienly cultivation techniques currently deployed on rice such as SRI, 3 reduction 3 gain, hence the economic effectiveness from material reduction has not been generated, causing higher production cost.

As the same cases of husk using for ask and biochar, the benit of husk from fumigated husk production for using as substraite to produce seedling also significantly high. It is estimated that the cost for 1 kg of fumigated husk (from 3kg of husk) is 3,520đ. Meanwhile, fumigated husk can be sold at 5000đ/ kg,bringing a profit of 1,480d. The added value of 1 kg of husk is, therefore 390VND. As a result, total income of husk owners and husk users to produce fumigated husk is 790 VND/ kg in Hanoi and 1,140VND/kg in An Giang, let alone added values derived from reduction of greenhouse gas emission. Meanwhile, there exists a great demand for fumigated husk used for making soil for seedling and planting high value vegetables.

4.7. Initial Environmental Examination screening matrix & recommendations

It is obviously recognized that the strengthening and diversification of rice husk use will bring clear environmental effects.

First of all, the strengthening utilization of husk will contribute to environmental protection in milling facilities, relief of water pollution and traffic jam. According to previous reports (prior to 2010), few farmers use husk as fuel or to cover the field, resulting in a great volume of husk left unused at milling facilities (especially in Mekong River Delta provinces). The composition of husk has caused pollution to the habitat and water. Husk dumped into the river has blocked the flow, retarding the water traffic. Recently, farmers have learnt to use husk as a recycled energy source, whereby virtually mitigating environmental pollution.

Secondly, the alternatively use of husk as biochar, fumigated husk, covering field, bio-carpet for fuel will help minimize greenhouse gas emission. Thought the use of husk as fuel to produce bricks bring high benifit for husk users and post-husk products. However, this usage causes environmental pollution due to greenhouse gas emission, similarly to direct husk burning. According to Gadde & cs., 2009, one ton of husk when burnt will emit 1.49 ton of CO_2. Therefore, given the fact that 75% of husk produced in Mekong River Delta is burnt to produce bricks, 4.13 million tons of CO_2 will be emitted. Losses caused by the use of husk to bake bricks to the people have been calculated in detail as mentioned above (economic efficiency). Hence, the use of alternative techniques, especially biochar using can bring great environment effect from reduction of GHG emission.

Thirdly, the use of husk for biochar, composting, bio-carpet then becoming fertilizerwill helpfertise soil, improving soil fertility and reduce the use of chemical fertilizers, contributing to a sustainable agriculture. Evaluation by Research Institutes shows that continuous use of organic substances such as biochar for many years will increase Carbon and nutrition in soil markedly. Physical properties of soil are significantly improved (Annex 13). That will enable sustainable exploitation and use of exhausted land by farmers in Vietnam.

To have full data of environment impact, the measuring of GHG emission from different husk using manners such as fuel for brick production, ask production, biochar production as improved conventional technology and in brick oven. Also the observation should be conducted on side effect of biochar on the reduction of chemical use for complementing to invisible effect of new technology.

4.8. Risks, assumption and uncertainty

Following risks may arise from the implementation of the pilot model, which deserves proper concerns to ensure certain success.

- **Risks from husk shortage in biochar production**

  In the Red River Delta, husk is mainly used by farming households for manure or land reclamation. Therefore, conversion of the use of husk into biochar production for manure is quite realistic. On the other hand, biochar is produced in improved traditional methods which are very familiar with farmers and will certainly be welcome. Meanwhile in Mekong River Delta, husk is used as a stable source of fuel. Therefore, model scale-up may face disadvantage without proper reconciliation of interests of various user targets (brick producers, biochar producers and users). Consequently, the model is required to demonstrate the benefits of biochar production to brick producers. Husk sources in Mekong River Delta are used in a concentrative manner by farmers to a great extent (on large cultivation areas). As a result, application of small-scale production by farming households is not realistic. Therefore, concentrative biochar production should be applied, following the technology of burning in brick kilns to make full use of existing facilities to reduce investment in burning devices.

- **Risks from uncertainties that reduce economic efficiency of the model:**Calculation of economic efficiency of the use of biochar on rice shows that the resulting benefits are not so high or stable. The model will demonstrate its strengths with added values generated from environmental effects and incomes from rotated crops (vegetables), added values from safe vegetables and reduction of supply consumption when biochar use is integrated into improved rice production or environment-friendly production following 3 increases– 3 decreases model. However, in the 3 increases– 3 decreases model, supplies will depend much on production environment (e.g. pesticides to prevent pests), which may affect the economic efficiency of the model. Therefore, effective management of uncertainties is required for the success of the model. If necessary, the model may be adapted.

PART 5. ANNEXES

Annex 1.Summary of information responding on rice husk use(August, 2013)

Criteria	Centre organization	Hanoi	An Giang
Number of secondary report collected	13	5	2
Number of expert interviewed	4		
Number of Leader	3	6	2
Number of farmer		59	64
Number of rice miller		15	9
Location surveyed(10 communities of 5 districts, 2 provinces)		i. Cổ Loa - Đông Anh; ii. Việt Hùng - Đông Anh iii. Đại Nghĩa - Mỹ Đức iv. Phù Lưu Tế - Mỹ Đức **(4 communities of 2 districts)**	i.Hòa Lạc- Phú Tân ii.Phú Bình-Phú Tân iii. Hòa Bình-Chợ Mới iv. Kiến An-Chợ Mới v. Vĩnh Thạnh Trung- Châu Phú vi. Mỹ Phú-Châu Phú **(6 communities of 3 districts)**

Annex 2. List of Managers and Experts responding information in byproduct use in Vietnam (August, 2013)

No.	Name of responder	Address
1	TS. Cao Việt Hưng	Devision of Fertilizer, Dept. of Crop Production – MARD
2	ThS. Nguyễn Trường Giang	Climate change Unit, Depat. of Science, Technology and Environment, MARD
3	TS. Ngô Tiến Dũng	Vice Director –Plant Protection Deprt.
4	ThS. Lê Sơn Hà	Head of quality Management, Pant Protection Deprt.
5	TS. Mai Văn Trịnh	Vice Director General, Institute for Agriculture Environment (IAE)
6	Ths. Trần Viết Cường	IAE
7	Nguyễn Công Vinh	Research Institute of Soil and Fertilizer

Annex3. List of local authorities responding information on rice husk use from Hanoi and An Giang (August, 2013)

No.	Name of responder	Address
1	Phạm Thị Hòa	Vice director of Depart. of Agriculture and Rural Development of An Giang
2	Nguyễn Thị Thoa	Head of Crop production Devision – Depart. of Agriculture and Rural Development of Hanoi
3	Nguyễn Thị Thúy	Devision of Crop Production, Deprt. of Agriculture and Rural Development of Hanoi
4	Nguyễn Thị Lương	Cổ Loa, Đông Anh, Hà Nôi
5	Nguyễn Thị Thu Hương	Cổ Loa, Đông Anh, Hà Nôi
6	Nguyễn Hữu Chung	Việt Hùng, Mỹ Đức, Hà Tây
7	Nguyễn Hữu Sáng	Việt Hùng, Mỹ Đức, Hà Tây
8	Lê Thị Kim Thủy	Đại Nghĩa, Mỹ Đức, Hà Tây
9	Lê Hồng Hải	Đại Nghĩa, Mỹ Đức, Hà Tây
10	Đỗ Thanh Phong	Ấp Trung 1, Thị trấn Phú Mỹ, Phú Tân, An Giang
11	Cao Văn Đủ	Trạm Khuyến nông Phú Tân, An Giang
12	Bùi Chí Công	Hòa Bình 9, Hòa Lạc, Phú Tân, An Giang
13	Nguyễn Thanh Nghĩa	Phú Tân, An Giang
14	Phan Công Nhũng	Xã Phú Bình, Phú Tân, An Giang

Annex 4. List of rice miller responding information on rice husk flow in Hanoi and An Giang (August, 2013)

No.	Name of responder	Village	Community	District	Province
1	Nguyễn Thị Oanh	Trung	Phù Lưu Tế	Mỹ Đức	Hà Nội
2	Nguyễn Đức Quế	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
3	Nguyễn Viết Minh	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
4	Nguyễn Thị Xuyên	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
5	Phạm Đình Thọ	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
6	Nguyễn Phương Anh	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
7	Nguyễn Văn Đình	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
8	Hà Thị Hiền	Lỗ Giao	Việt Hùng	Đông Anh	Hà Nội
9	Phạm Đức Cường	Lỗ Giao	Việt Hùng	Đông Anh	Hà Nội
10	Nguyễn Quang Huy	Lỗ Giao	Việt Hùng	Đông Anh	Hà Nội
11	Nguyễn Viết Phú	Lỗ Giao	Việt Hùng	Đông Anh	Hà Nội
12	Chu Thị Hoa	Nhồi	Cổ Loa	Đông Anh	Hà Nội
13	Hoàng Thị Phượng	Nhồi	Cổ Loa	Đông Anh	Hà Nội
14	Hoàng Thị Ngát	Nhồi	Cổ Loa	Đông Anh	Hà Nội
15	Lại Thị Thúy	Dõng	Cổ Loa	Đông Anh	Hà Nội
16	Nguyễn Công Tạo	Bình Thành 1	Hòa An	Chợ Mới	An Giang
17	Trương Thị Thùy Dương	Bình Thành 1	Hòa An	Chợ Mới	An Giang

18	Trần Thị Oanh	Bình Thành 1	Hòa An	Chợ Mới	An Giang
19	Nguyễn Văn Thật	An Mỹ	Hòa An	Chợ Mới	An Giang
20	Nguyễn Văn Út	An Mỹ	Hòa An	Chợ Mới	An Giang
21	Trương Văn Tường	An Thạch	Hòa An	Chợ Mới	An Giang
22	Trần Quốc Thái	An Thuận	Hòa Bình	Chợ Mới	An Giang
23	Nguyễn Văn Khoảnh	An Quế	Hòa Bình	Chợ Mới	An Giang
24	Nguyễn Văn Tùng	An Quế	Hòa Bình	Chợ Mới	An Giang

Annex 5. List of farmer responding information on rice husk use in Hanoi and An Giang (Oct.2013)

No.	Name of responder	Village	Community	District	Province
1	Nguyễn Văn Thành	Dõng	Cổ Loa	Đông Anh	Hà Nội
2	Nguyễn Thị Nha	Dõng	Cổ Loa	Đông Anh	Hà Nội
3	Lê Văn Ba	Nhồi	Cổ Loa	Đông Anh	Hà Nội
4	Đào Thị Dung	Dõng	Cổ Loa	Đông Anh	Hà Nội
5	Đỗ Thị Thủy	Dõng	Cổ Loa	Đông Anh	Hà Nội
6	Lê Thị Luyến	Dõng	Cổ Loa	Đông Anh	Hà Nội
7	Nguyễn Hữu Lân	Dõng	Cổ Loa	Đông Anh	Hà Nội
8	Đào Thị Loan	Dõng	Cổ Loa	Đông Anh	Hà Nội
9	Nguyễn Thị Sự	Dõng	Cổ Loa	Đông Anh	Hà Nội
10	Nguyễn Thị Sinh	Dõng	Cổ Loa	Đông Anh	Hà Nội
11	Nguyễn Thị Nên	Dõng	Cổ Loa	Đông Anh	Hà Nội
12	Lưu Thị Mẫn	Dõng	Cổ Loa	Đông Anh	Hà Nội
13	Nguyễn Thị Huệ	Dõng	Cổ Loa	Đông Anh	Hà Nội
14	Nguyễn Thị Cẩn	Dõng	Cổ Loa	Đông Anh	Hà Nội
15	Bùi Thị Hòa	Dõng	Cổ Loa	Đông Anh	Hà Nội
16	Nguyễn Thị Vận	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
17	Nguyễn Văn Chính	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
18	Nguyễn Thị Ngọc	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội

19	Lưu Thị Tuyền	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
20	Đàm Thị Thanh	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
21	Nguyễn Thị Lập	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
22	Nguyễn Thị Khuyên	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
23	Nguyễn Đức Thành	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
24	Nguyễn Thị Huệ	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
25	Nguyễn Thị Mai	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
26	Trần Thị Thẩm	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
27	Dương Thị Hà	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
28	Lê Văn Vương	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
29	Nguyễn Thị Đường	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
30	Lê Thị Vựng	Lỗ Giai	Việt Hùng	Đông Anh	Hà Nội
31	Lê Thị Hình	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
32	Lê Thanh Định	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
33	Lê Văn Tươi	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
34	Lê Nguyên Thục	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
35	Nguyễn Văn Vinh	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
36	Nguyễn Văn Hưng	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
37	Lê Ngọc Thạch	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
38	Lưu Thị Thúy	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
39	Lê Cao Nguyên	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
40	Lê Văn Thành	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
41	Lê Văn Lộc	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội

42	Nguyễn Trung Kiên	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
43	Nguyễn Văn Nguyên	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
44	Nguyễn Thị Nụ	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
45	Nguyễn Thị Nga	Văn Giang	Đại Nghĩa	Mỹ Đức	Hà Nội
46	Nguyễn Thị Tăng	Trung	Phù Lưu Tế	Mỹ Đức	Hà Nội
47	Nguyễn Danh Thanh	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
48	Trịnh Thị Bình	Trung	Phù Lưu Tế	Mỹ Đức	Hà Nội
49	Nguyễn Thị Thanh	Trung	Phù Lưu Tế	Mỹ Đức	Hà Nội
50	Trịnh Thế Biển	Thượng	Phù Lưu Tế	Mỹ Đức	Hà Nội
51	Nguyễn Thị Trang	Thượng	Phù Lưu Tế	Mỹ Đức	Hà Nội
52	Nguyễn Thị Phượng	Trung	Phù Lưu Tế	Mỹ Đức	Hà Nội
53	Nguyễn Công Nam	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
54	Nguyễn Thị Xoa	Thượng	Phù Lưu Tế	Mỹ Đức	Hà Nội
55	Nguyễn Viết Huấn	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
56	Trương Văn Chanh	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
57	Nguyễn Thị Dung	Thượng	Phù Lưu Tế	Mỹ Đức	Hà Nội
58	Nguyễn Sỹ Quảng	Thượng	Phù Lưu Tế	Mỹ Đức	Hà Nội
59	Nguyễn Duy Quyền	Hạ	Phù Lưu Tế	Mỹ Đức	Hà Nội
60	Trương Văn Lợi	Hòa Bình 3	Hòa Lạc	Phú Tân	An Giang
61	Lê Văn Be	Hòa An 2	Hòa Lạc	Phú Tân	An Giang
62	Phạm Văn Cầu	Hòa Bình 2	Hòa Lạc	Phú Tân	An Giang
63	Nguyễn Tri Phương	Hòa Bình 2	Hòa Lạc	Phú Tân	An Giang
64	Trần Thanh Song	Hòa Hưng 1	Hòa Lạc	Phú Tân	An Giang

65	Bùi Thanh Tùng	Hòa Bình 1	Hòa Lạc	Phú Tân	An Giang
66	Nguyễn Văn Sĩ	Hòa Bình 1	Hòa Lạc	Phú Tân	An Giang
67	Trần Ngọc Tấn	Hòa An	Hòa Lạc	Phú Tân	An Giang
68	Quách Văn Thi	Hòa An	Hòa Lạc	Phú Tân	An Giang
69	Trần Thanh Nghệ	Hòa Bình	Hòa Lạc	Phú Tân	An Giang
70	Hồ Ngọc Lợi	Hòa Bình 1	Hòa Lạc	Phú Tân	An Giang
71	Võ Thanh Nhàn	Hòa Bình 1	Hòa Lạc	Phú Tân	An Giang
72	Dương Văn Tràm	Hòa Bình 1	Hòa Lạc	Phú Tân	An Giang
73	Nguyễn Văn Lớn Em	Hòa Bình 2	Hòa Lạc	Phú Tân	An Giang
74	Dương Văn Thắm	Hòa Bình 3	Hòa Lạc	Phú Tân	An Giang
75	Nguyễn Trường Chinh	Hòa An	Hòa Lạc	Phú Tân	An Giang
76	Huỳnh Ngọc Đỉnh	Hòa Hưng 1	Hòa Lạc	Phú Tân	An Giang
77	Đặng Văn Lao	Hòa Hưng 1	Hòa Lạc	Phú Tân	An Giang
78	Thái Văn Em	Hòa Hưng 2	Hòa Lạc	Phú Tân	An Giang
79	Nguyễn Văn Sang	Hòa Hưng 2	Hòa Lạc	Phú Tân	An Giang
80	Trần Minh Triết	Hòa Bình 3	Hòa Lạc	Phú Tân	An Giang
81	Lê Văn Bổn	Thị trấn	Hòa Lạc	Phú Tân	An Giang
82	Nguyễn Văn Tuấn	Thị trấn	Phú Bình	Phú Tân	An Giang
83	Nguyễn Văn Rồi	Thị trấn	Phú Bình	Phú Tân	An Giang
84	La Văn Đảo	Bình Phú 2	Phú Bình	Phú Tân	An Giang
85	Nguyễn Như Hoàng	Bình Thành	Phú Bình	Phú Tân	An Giang
86	Võ Văn Non	Bình Phú 2	Phú Bình	Phú Tân	An Giang

87	Phạm Thị Buộc	Bình Phú 1	Phú Bình	Phú Tân	An Giang
88	Ngô Văn Giang	Bình Thành	Phú Bình	Phú Tân	An Giang
89	Ngô Văn Nguyên		Phú Bình	Phú Tân	An Giang
90	Nguyễn Văn Hồng	Bình Thành	Phú Bình	Phú Tân	An Giang
91	Trần Văn Say	Bình Thành	Phú Bình	Phú Tân	An Giang
92	Nguyễn Văn Dũng	Bình Thành	Phú Bình	Phú Tân	An Giang
93	Trần Quốc Thái	An Thuận	Hòa Bình	Chợ Mới	An Giang
94	Nguyễn Văn Minh	Long Hạ	Kiến An	Chợ Mới	An Giang
95	Phạm Văn Tính	Long Hạ	Kiến An	Chợ Mới	An Giang
96	Ngô Hồng Giang	Phú Thượng 2	Kiến An	Chợ Mới	An Giang
97	Nguyễn Văn Dựng	Long Hạ	Kiến An	Chợ Mới	An Giang
98	Nguyễn Văn Cường	Long Hạ	Kiến An	Chợ Mới	An Giang
99	Nguyễn Văn Thư	Long Hạ	Kiến An	Chợ Mới	An Giang
100	Nguyễn Văn Sang	Long Hạ	Kiến An	Chợ Mới	An Giang
101	Phạm Văn Định	Long Hạ	Kiến An	Chợ Mới	An Giang
102	Nguyễn Văn Giàu	Long Hạ	Kiến An	Chợ Mới	An Giang
103	Nguyễn Văn Lực	Long Hạ	Kiến An	Chợ Mới	An Giang
104	Lê Văn Lâm	Long Hạ	Kiến An	Chợ Mới	An Giang
105	Lê Văn Bàu	Long Bình	Kiến An	Chợ Mới	An Giang
106	Huỳnh Văn Cảnh	Vĩnh Hòa	Vĩnh Thạnh	Châu Phú	An Giang
107	Phan Huy Thiệp	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
108	Nguyễn Văn Trường	Vĩnh Quý	Vĩnh Thạnh	Châu Phú	An Giang

			Trung		
109	Trần Văn Bé	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
110	Nguyễn Văn Thành	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
111	Lê Hoàng Dũng	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
112	Trịnh Văn Phú	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
113	Nguyễn Văn Quang	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
114	Nguyễn Thị Nia	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
115	Nguyễn Văn Hoàng	Vĩnh Quý	Vĩnh Thạnh Trung	Châu Phú	An Giang
116	Nguyễn Thị Nguyệt	Bình Tân	Bình Mỹ	Châu Phú	An Giang
117	Ngô Văn Tức	Mỹ An	Mỹ Phú	Châu Phú	An Giang
118	Đào Vũ Đồng	Mỹ An	Mỹ Phú	Châu Phú	An Giang
119	Dương Văn Tính	Mỹ An	Mỹ Phú	Châu Phú	An Giang
120	Triệu Văn Ngoan	Mỹ An	Mỹ Phú	Châu Phú	An Giang
121	Phạm Thị Vén	Mỹ An	Mỹ Phú	Châu Phú	An Giang
122	Lê Văn Tạo	Mỹ An	Mỹ Phú	Châu Phú	An Giang
123	Trần Minh Chánh	Mỹ An	Mỹ Phú	Châu Phú	An Giang

Annex 6. The area of major during 2000-2020

Crop	Area (Thous. Ha)					
	2000	2005	2010	2012	2015	2020
Rice	7666.3	7324.8	7489.4	7753.2	7030	7000
Corn	730.2	1052.6	1125.7	1118.2	1200	1200
Cassava	237.6	425.5	498.1	470	400	380
Pea nut	244.9	269.6	210.3	220.5	300	350
Soy bean	124.1	204.1	173.6	120.8	370	450
Suggar cane	302.3	266.3	269.1	297.5	300	300
Sweet potato	254.3	185.3	150.8	175	175	175

Source: MARD, 2012; Stretagy of Agriculture Development 2011 - 2020

Annex 7. Estimation of productivity of major crop during 2000-2020

No.	Crop	Productivity (Thous. tons)					
		2000	2005	2010	2012	2015	2020
1.	Rice	32529.5	35832.9	39185.0	43650.5	39869.0	41300.0
2.	Corn	2005.9	3787.1	5280.0	4800.0	6480.0	7200.0
3.	Cassava	1986.3	6716.2	9000.0	9400.0	9400.0	11400.0
4.	Pea nut	355.3	489.3	575.0	470.6	720.0	980.0
5.	Soy bean	149.3	292.7	351.9	175.2	740.0	1125.0
6.	Suggar cane	15044.0	14948.0	19500.0	20700.0	23100.0	25500.0
7.	Sweet potato	16110	1443.0	1653.0	1531,2	1600,0	1750,0

Source:*MARD, 2012*

Annex 8.Potentiality of byprofuct from crop production sector in 2012

Source of byproduct	Quantity (Mill.tons)	(%)
Rice straw	43.65	64.2
Rice husk	8.73	12.8
Corn	5.76	8.5
Pea nut	2.42	3.6
Sugar cane	4.04	5.9
Others	3.37	5.0
Total	67.97	100.0

Source: IAE, 2012

Annex 9: Dynamic of rice husk quantity during the period of 2005 – 2012 (Mill. tons)

Area	2005		2010		2012	
	Rice	Husk	Rice	Husk	Rice	Husk
Whole country	35.83	7.17	40.05	8.00	43.65	8.73
Red River Delta	6.398	1.28	6.80	1.36	7.20	1.44
Ha Noi	1.89	0.38	1.13	0.22	1.13	0.26
MK River Delta	19.30	3.86	21.60	4.32	24.200	4.84
An Giang	3.15	0.63	3.65	0.73	3.08	0.62

Source: IAE, 2012

Annex 10.Cost and income from brick production with rice husk (for 120,000 brick)- An Giang Oct. 2013

Expenditure	Unit	Quantity	Price unit	Cost and income (VND)
Production cost				
Unheating brick	Individual	120.000	250	30.000.000
Rice husk	Ton	24	500.000	12.000.000
Labor cost for loading brick	Labor day	15	200.000	3.000.000
Labor cost for husk supplying	Labor day	10	200.000	2.000.000
Labor cost for unloading	Labor day	15	200.000	3.000.000
Cost for transportation	Labor day	10	200.000	2.000.000
Tax				2.000.000
Total cost				54.000.000
Income				
Brick selling	Individual	120.000	500	60.000.000
Benefit				6.000.000

Annex 11: Influence of biochar Pyrolyzed from rice husk after continuous use on rice during 2 crop seasons on soil physical and chemical in Long An province

Chemical index

Treatment	pHH_2O	pH_{KCl}	OC	N	P_2O_5	K_2O	CEC	BS
			(%)				(meq/ 100g)	(%)
No fertilizer	5.8	5.1	0.68	0.07	0.04	0.04	4.2	41.8
120N + $60P_2O_5$ + $70K_2O$	5.9	5.1	0.71	0.06	0.05	0.04	4.2	49.9
4 tons biochar + 90N + $60P_2O$+$70K_2O$	6.1	5.3	0.98	0.08	0.04	0.05	5.2	50.7
8 tons biochar + 90N + $60P_2O$ + $70K_2O$	6.1	5.5	0.99	0.09	0.05	0.06	5.9	51.8
LSD5%	0.1	0.5	0.07	0.01	0.003	0.009	0.57	1.8
CV%	1.2	10.6	4.7	8.6	4.7	10.8	6.7	3.9

Soil physical

Treatment	Density g/cm^3	Propotion g/cm^3	Porosity (%)	Physical component (%)			
				Clay soil<*0,002mm*	Limon 0,02-0,002mm	Fine sandy 0,02-0,2mm	Coarse sandy 0,2-2,0mm
Check (No fertilizer)	1.63	2.87	43.2	21.9	53.0	11.2	13.9
120N + $60P_2O_5$ + $70K_2O$	1.62	2.87	43.6	20.8	53.2	12.4	13.6

4 tấn Biochar + 90N + $60P_2O$+$70K_2O$	1.58	2.87	44.9	22.5	54.4	11.9	11.2
8 tấn Biochar + 90N + $60P_2O$ + $70K_2O$	1.57	2.90	45.9	22.3	53.6	13.6	10.5

Source: Tran Viet Cuonget al., IAE, 2012.