

# Management and Reduction of Burning Practice in **Agricultural** Areas and Policy Recommendations to Tackle **PM<sub>2.5</sub>** in **Thailand**

# Management and Reduction of Burning Practice in **Agricultural** Areas and Policy Recommendations to Tackle **PM<sub>2.5</sub>** in **Thailand**

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# Introduction

Open burning of agricultural residues in agricultural lands is one of the major sources of air pollution especially fine particulate matter having aerodynamic diameter not larger than 2.5 micrometer ( $PM_{2.5}$ ). Studies have found that the burning agricultural residues left from the cultivation of 3 main cash crops, i.e. rice, sugarcane, and maize, contribute significantly to  $PM_{2.5}$  in both rural and urban areas.

The government and relevant stakeholders have recognized and placed the importance of solving the problem of fine particulate matter at high priority. Consequently, the Cabinet has made it as the National Agenda of the country on 12 February 2019. Subsequently, the Action Plan to Drive the National Agenda “The Mitigation of Particulate Pollution” was adopted as the resolution of the Cabinet on 1 October 2019 which an along with setting guidelines and measures under the National Agenda Action Plan in 2019. Integrated efforts have been also made by various sectors to control, regulate and mitigate the particulate problem, in particular  $PM_{2.5}$ , during the critical period and at the sources, in addition to the improvement of management efficiency. However, it is still not keeping up with the situation of air pollution problems that still tend to be high and exceed the standard.

The study was conducted under **the project to develop guidelines for burning management in farmland to solve  $PM_{2.5}$  problems in Thailand.** Through the cooperation of the **Thailand Environment Institute** together with **Pure Earth** and **related agencies to conduct an action study.** The project employed participatory study process by brainstorming from groups of rice, maize and sugarcane farmers in the target areas in order to provide guidelines for the management and reduction of burnt in farmland and policy proposals to address  $PM_{2.5}$  problems and this will be beneficial and support the implementation of related operations in the future.

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## **Situations, directions and policies related to management of burning in cultivated areas**

Open burning in agricultural areas is one of the main sources of air pollution especially  $PM_{2.5}$  suspended particulate matter which can be found in both rural and urban areas. Since Thailand is an agricultural country, the main economic crops are planted in all regions of the country. However, at present, farmers aim mainly on productivity so burning is an easy method. It is convenient, fast and economical that farmers are widely used whether burning sugarcane for the factory, soil preparation for rice and maize cultivation as well as burning, waste after planting and so on.



The problem of agricultural burning usually arises from 3 main economic crops; rice, sugar cane and maize. The burning was found in 47% of mill sugarcane plantation, 57% of off season rice cultivation, 29% of in season rice cultivation and 35% of maize cultivation (Attavanich and Pengthamkeerati, 2018). Most farmers have found that agricultural waste burning can save cost such as the cost of hiring labor. It is more convenient and faster and shorten crop cycle times, thus enabling greater harvesting, collecting and transporting of crops. Plowing is also easy. Moreover, it can control pests, insects, plant diseases and weeds, etc. Although at present, various size of agricultural machines are used in the fields to replace burning such as preparing the soil with a tractor and harvesting with a grass chopper machine. However, it still has a high cost and hard to own and maintenance the machines.

The Government and other related sectors have realized the importance of solving the problem of dust pollution and raised it on the national agenda and

set guidelines and measures under the National Agenda Action Plan at the end of 1983 by integrating the control, supervision and reduction of air pollution emission from sources. For the purpose of maintaining air quality within the standard and reducing the impact on public health and other related impacts.

The directions and policies of the country are consistent with the sustainable development goals which aim to ensure sustainable consumption and production as well as to reduce the emission of waste or pollutants into the air, water and soil. As a result, to minimize the negative impact on health and the environment as much as possible and there are also many laws related to the management of open burning.





## The essence of the relevant policies and plans



**Constitution of the Kingdom of Thailand (2017)** State policy should provide measures or mechanisms that enable farmers to carry out their activities effectively, high volume and high quality output, safe, low cost and competitive.



**The National Strategy (2037-2018), the 12th National Economic and Social Development Plan (2021-2017) and the Environmental Quality Management Plan (2021-2017)** focus on green consumption and production, create a system of surveillance, monitoring and control of pollution in the manufacturing sector. Reduce emissions and environmental impacts to drive the economy together with efficient use of resources, green growth for sustainable development, create a good quality of life, reduce pollution, and reduce impact on health and ecosystems, solve the smog crisis for air quality to be in the standard and focus on creating value from the bio-resource and bio-agricultural based to reduce waste material.



**National Agenda Action Plan Solving the Problem of Dust Pollution (2020)** The Special Plan to Solve the Problem of Dust Pollution for relevant agencies to take action in solving dust problem especially during the crisis



**Master Plan for Climate Change (2050-2015)** greenhouse gas emission, determine the proportion of burning of agricultural land and management of agricultural waste

**Fiscal Measures** The government has set a budget for environmental support approximately 10,945-3,929 million baht or 0.4 percentage of the 2019 annual budget. Moreover, there is a total integrated budget plan of the Pollution Control Department but the number is small compared to the responsibility on the environment.

The reoccurrence of very high concentration of suspended particulate matter in early months of recent years has driven relevant agencies to jointly formulate guidance and measures to address PM<sub>2.5</sub> pollution problems in Bangkok, its vicinities and other provinces with similar problems. In acknowledgement of such action, the cabinet adopted «addressing suspended particulate matter» as a national agenda and assigned the

Ministry of Natural Resources and Environment to develop an action plan for the national agenda. The National Environment Board later endorsed the action plan as a general guidance for actions at the national level and for areas with critical situation in order to integrate efforts across various sectors and provide clear directives for relevant agencies. The action plan consists of 3 main measures as follow;



## Measures taken during the critical situation



### **Measure 1**

increase effectiveness and stringency in administration of respected jurisdictions, enabling authorities to promptly issues commands for actions, particularly in areas with critical situation such as Bangkok and its vicinities as well as 17 northern provinces.



### **Measure 2**

prevention and reduction of pollution at source, including vehicles, industry and open burning, for example, considering tax benefits for cars and fuel that are equivalent to Euro5 before the legal date.



### **Measure 3**

increase effectiveness of pollution management and develop additional networks for air quality surveillance in order to enhance monitoring in areas where air quality forecast models are available.





The action plan for mobilization of efforts to address the national agenda on suspended particulate pollution is implemented under supervision of the communication sub-committee on air pollution and technical sub-committee on air pollution which are subsidiaries of the National Environment Board. Actions taken by the sub-committees include;

- 📍 **Establish a War Room** to solve air pollution problems.
- 👤 **Appoint a spokesperson for PM<sub>2.5</sub>** pollution to communicate to the public.
- 📅 **Organize meetings** to discuss the integration of operations with relevant agencies.
- 📣 **Communicate and publicize** to the target groups periodically, through various campaigns such as “Thai Roo Soophoon” (Thai people know how to fight dust), “Thai people take personal responsibility for the public” and “New normal, good life starts with us”.

Additional measures have been proposed by the Technical Working Group on Air Pollution for the period during 2014 -2020 and also consisted of actions related to agricultural sector and open burning as follow;

- 📍 **Provide a clear burning plan** to support and explain to farmers in order to organize the burning that does not affect the environment effectively.
- 🚫 **Forbidden open burning in residential areas** and there are penalties for polluters (Bangkok Metropolitan Authority and other provincial administrations)
- 📄 **Promote establishment of markets for renting farming machinery** (Ministry of Agriculture and Cooperatives and Ministry of Finance) and increasing the difference in the purchase of burnt and fresh sugarcane (Ministry of Industry)
- 💰 **Provide financial aids to farmers with conditions that discourage open burning** (Ministry of Agriculture and Cooperatives)
- 📚 **Encourage and educate farmers to manage plots for using machines and promote the integration of plots** (Ministry of Agriculture and Cooperatives)
- 💡 **Promote the use of agricultural waste** for biomass power generation (Ministry of Energy)



In addition, there is a solution to the problem of pollutants during the crisis period of 2020-2021. The guidance consists of (1) measures to address pollution from motor vehicles; (2) measures to address pollution from industries and open burning and; (3) legal measures to address suspended particulate matter. For each area, actions taken during this critical period followed the action plan for mobilization of efforts to address the national agenda on suspended particulate matter when the pollutants' concentration does not exceed level 1-3. In the fourth level area ( $PM_{2.5}$  values are greater than 100 microgram/cubic meter) should be submitted to the National Environment Board for consideration and submission to the Cabinet.

At present, the draft action plan for the National Agenda to Solve Dust Pollution Problems (2020) and the Task Force on solving dust pollution problems according to the Cabinet Resolution on November 2020, 23<sup>th</sup> are still in the process of consideration and approval of the Office of the National Economic and Social Development Council for further consideration by the Minister.

The plan of actions on suspended particulate pollution consists of 12 measures. These measures were endorsed by the Cabinets and aim to provide directives for relevant agencies in taking actions during the critical periods in various areas such as public relations, and communication to create awareness among the target group, management of fuel materials by collecting, transporting and utilizing waste materials. Build a network of volunteer as the main mechanism for accessing areas for communication, monitoring, surveillance and extinguishing fires. The measures can be listed as follow;

1. **Communication and public relations** by creating awareness to cover all target groups by appointing the communication sub-committee on air pollution and formulating a public relations plan.  
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2. **Appointing a sub-committee on prevention and mitigation of forest fire, smog and suspended particulate pollution** under the National Committee on Disaster Prevention and Relief in order to provide a mechanism for handling the situations.  
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3. **Management of fuel materials in forest** by collecting, moving and utilizing waste materials and manage fuel in 17 northern provinces.  
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4. **Developing** a network of volunteers as the main mechanism for accessing areas including communication, monitoring, surveillance and fire suppression.  
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5. **Accelerate the implementation** of reforestation and forest fire prevention projects under the Royal Volunteer Administration Center, targeting 12 provinces by 2020 and complete 76 provinces by 2027.  
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6. **Accelerate the efficiency of the transfer of forest fire control missions** to the local administrative organizations.



7. **Inform the dust forecast to the public** 3 days in advance.  
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8. **Apply satellite imagery in spatial reporting** of suspended particulate matter and it has been used since December 1, 2020.  
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9. **Develop forecasting and decision support** systems including development and use of a forest fire extinguishing command application.  
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10. **Administrate fuel management** by using the fuel management registration application.  
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11. **Engage people to take part in forest care** and reduce forest burning through community land management.  
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12. **Build cooperation** with neighboring countries at the ASEAN level, bilateral level and border area level.





## **The situation of burning management in cultivated areas**

An assessment on management of burning under the project to develop guidelines for management of open burning in cultivated areas as an effort in addressing PM<sub>2.5</sub> problems in Thailand was a participatory study. It was conducted in association with 3 target groups of farmers which are rice farmers in Ayutthaya Province, maize farmers in Lop Buri Province and sugarcane farmers in Uthai Thani Province. The assessment reflected not only the technical aspects of situations related to the burning and its management but also opinions and advices from representatives of farmers and relevant agencies who involved in the area



## **Agricultural sector and situations on the burning in cultivated areas**

In Thailand, cultivated areas covers around 40-50% of the country and accommodate nearly 6 million households of farmers. Approximately 35% of the country's labor force or over 12 million people earn their living in agricultural sector. A 2020 report by Office of Agricultural Economics identifies rice, maize and sugarcane as the economic crops during 2019-2020 and noted that rice were harvested during farming season from a total area of 8.64 million hectares while off-season rice was harvested from a total areas of 10.12 million hectares. The report further pointed out that a total areas of 9.36 million hectares was used for harvesting maize and sugarcane from a total area of 1.83 million hectares. A 2018 report by Attavanich and Pengthamkeerati as mentioned above, can be seen that 47% of burning sugarcane, 57% of burning off season rice, 29% of burning paddy rice and 35% of burning maize.

Department of Alternative Energy Development and Efficiency (2013) found that the area after harvesting of each type of three major economic crops was a difference in the ratio of agricultural waste to the amount of production. For every ton of rice, 0.49 tons of straw are produced while 1.84 tons of stems and leaves and 0.24 tons of cobs are produced for each ton of maize. Around 0.17 tons of leaves and shoots are produced for every ton of sugar cane.

Moreover, the above information on the proportion of agricultural waste, calculations were made by Land Development Department (2015) and Zhang et al. (2018) on emission of  $PM_{2.5}$  pollutants. The calculation indicated that over an area of 1,600 square meters, opening burning of rice straw would result in  $PM_{2.5}$  emission of 4.18 kilograms equivalent, burning of corn leaves, stems and cobs would emit  $PM_{2.5}$  pollutants of 3.09 kilograms equivalent and burning of sugarcane leaves and shoots would generate  $PM_{2.5}$  pollutants of 17.60 kilograms equivalent.



The calculations were also made on the annual amount of the cash crops yield and PM<sub>2.5</sub> emission from opening burning of such products. This reflects the ratio of agricultural waste to the yield in major cash crops. Cultivation of commercial sugar cane was found to produce highest amount of PM<sub>2.5</sub> pollutants (94,900 tons/year), followed by in-season rice farming (65,900 tons/year), off-season rice cultivation (15,100 tons/year) and maize farming (6,300 tons/year), respectively (as shown in the Table 1 below).

**Table 1: Calculation of PM2.5 emission caused by opening burning of cash crops**

Crops	Harvest area (km <sup>2</sup> ) <sup>1</sup>	Burning (%) <sup>2</sup> / area (km <sup>2</sup> )	Dry biomass (kg./ 1,600 m <sup>2</sup> ) <sup>3</sup>	PM <sub>2.5</sub> (kg./ 1,600 m <sup>2</sup> ) <sup>4</sup>	Calculation <sup>5</sup>	
					Dry biomass (million tons/year)	PM <sub>2.5</sub> (ten thousand tons /year)
sugar cane	11.46	47% / 5.39	4,272	17.60	23.03	9.49
Rice (in-season)	54.39	29% / 15.77	329	4.18	5.19	6.59
Rice (off-season)	6.33	57% / 3.61	329	4.18	1.19	1.51
maize	5.85	35% / 2.05	330	3.09	0.68	0.63

- Sources:**
1. Office of Agricultural Economics (2020)
  2. Attavanich and Pengthamkeerati (2018)
  3. Land Development Department ( 2015)
  4. Zhanget al. (2018)
  5. Calculation made by the project

Based on the above harvest spatial forecasts, sugarcane plantations were noted for generating the greatest amount of  $PM_{2.5}$  pollutants. However, burning of sugarcane leaves has, in fact, been significantly diminishing in recent years due to the state policy against such practice and cooperation of farmers to supply sugar factories with freshly cut sugar canes. The extend of burning in paddy fields during farming seasons generally correlates with the size of farming areas and reduction of the

burning could be a viable option in enabling significantly reduction of sources for  $PM_{2.5}$  emission. Burning of rice straws during off-season farming was found to increase with numbers of cultivation as indicated by the rise in number of hotspots. The burning itself remains comparatively limited and is mostly found in irrigated areas of Central Thailand while burning in maize farms has the least impact on  $PM_{2.5}$  air pollution emissions.

### **The state of cultivation in target sites**

Concerning management of open burning in the study sites of Ayutthaya, Lop Buri and Uthai Thani Provinces, the air quality at the sites was found to range from moderate to excellent and no significant health impact from suspended particulate matter pollution was reported. Open burning at the sites was found during pre-cultivation and post-harvest periods which were related to the number of hotspots of the country and the harvested area for economic crops.

#### **• Rice cultivation in Ayutthaya Province**



In 2019, approximately 125,187.04 hectares of lands in Ayutthaya Province were used for cultivation of rice during the farming season and produced 506,339 tons of rice. Roughly 114,784.32 hectares used for off-season farming in 2019 and were reduced to 694.608 square kilometers in 2020 due to drought. As a result, the yield decrease by almost half compared to the year 2019 (Office of Agricultural Economics, 2020)

Most of rice farmers in Ayutthaya Province plant rice twice a year. The first crop is cultivated during November- April, in order to avoid damage from flooding. The second crop is grown during May-September. Starting from cultivation until harvesting by using water from the irrigation system, using light rice varieties for faster harvesting and most of the sowing methods are used and some of which are done by transplanting.

The burning of rice stubble in the rice fields has been found mainly in April, to speed up the plowing in the second round of farming so that the rice can be harvested in time for the flood season. (Department of Agricultural Extension 2016)



### ● Maize cultivation in Lop Buri Province

In 2019, approximately 46,754.4 hectares of land in Lop Buri Province were used for cultivation of maize and yielded roughly 205,037 tons of harvest. The size of maize farms was however less than that in 2018 (Office of Agricultural Economics, 2020). Maize farming in Lop Buri Province occurs in two periods. The first is planted after rice cultivation during March - October and harvested in June - February. The second is only cultivated in areas with irrigated water sources or areas with access to water supply, planted during November-February and harvested in the months of February - May. Most maize farmers prefer farming during the first period since the average harvest per 1,600 square meters tends to be higher. Such farming was also encouraged by the government as an alternative to off- season rice cultivation in order to mitigate the problem of rice oversupply. Cultivation of maize







also uses 2-3 times less water than off-season rice farming and can be harvested quicker by 100-120 days (Department of Agriculture, 2019).

Burning corn stubble is most common in the post-harvest period. Cobs and corn leaves in the field are burned to facilitate soil preparation for the next production season.

At present, the burning of corn stubble in the area has been reduced compared to other crops by switching to other types of crops.

### **Sugar cultivation in Uthai Thani Province**

In 2020, sugarcane cultivation in Uthai Thani Province covered a total area of approximately 57,051.68 hectares, yielding 3,715,056 tons of harvest. The harvest was found to increase from that

in 2019 by 10,344 tons despite the reduction in farming areas by 376 hectares (Office of Agricultural Economics, 2020).



Burning of sugar leaves occurs during pre-cultivation, pre-harvest and post-harvest periods. Pre-harvest burning generally occurs due to labor shortage and the need to quickly deliver the harvest to sugar factories. Large amount of leaves and other byproducts generated after harvesting present a significant obstruction to fertilize and tillage in farmlands. Burning is therefore an option to make it easier to plow the soil for the next farming season (Department of Agriculture).



Data from factories that have purchased sugarcane in Uthai Thani province, during the farming season of 2020-2021, there were about 430,000 tons, divided into 70% fresh sugarcane and 30% burnt sugarcane. The amount of burnt sugarcane had been decreased by 66% from the previous year. This is a result of sugarcane farmers cooperate to cut fresh sugarcane according to the government's policy. They also collect and sell sugarcane leaves to sugar factories to use as fuel for renewable electricity generation within the factories.

The number of hotspots in the study areas in all 3 provinces, comparing the 2020 data with the year 2019, tends to increase continuously. Phra Nakhon Si Ayutthaya Province found the number of cumulative hotspots 813, down from 823 in 2019, in relation to the decrease in plantations because of the drought. Lopburi Province found the cumulative number of 2,146 spots, an increase from 1,168 spots in 2019. In Uthai Thani province found the cumulative number of 6,627 spots, an increase from 296 spots in 2019, relative to both the province and country overview (Space Technology and Geo-Informatics Development Agency, Public Organization, 2020). Due to the increased cultivation area, the amount of fuel from rice straw, rice stubble, leaves and sugarcane shoots has been increased accordingly.



## Summary of opinions on the management of burning in farmland

From the interviews with farmers and representatives of local government agencies as well as a small group meeting of stakeholders reflecting their views on the management of open burning in plantations as follows:

**Leaders of farmers** viewed that farmers have already adopted and adjusted their burning management at the practical level by starting to overlap the burning time. Therefore, it is reduced according to the government's campaign. However, there are problems with the management of open burning in farms, factors such as the need to reduce production costs and labor shortages, shortage of machinery used

to reduce open burning and difficult to access and own, including the increase costs for the maintenance of those machines as well. The group of farmers has been gathered but they are not ready to take the risk of interest on loan to manage within the group, if borrowing to buy production factors.

Therefore, the farmers suggested that the relevant agencies should provide funding support for machinery and technology to increase the capacity of necessary production factors such as water resources and water resources management, increase better understanding through training and study visits on marketing management and maintain communication to change attitudes and behaviors to reduce burning and so on.

**Representatives of relevant agencies at the local level**

viewed that the agencies at the higher level had given importance and emphasized on solving the problem of open burning in farmland through the campaigns and awareness raising on the importance and necessity of prohibiting burning. The enforcement of relevant laws is still difficult to implement. Cultivation of cash crops in highlands has a higher chance of burning than in plains because the use of machinery is still limited to the condition of the area and its price is too expensive for farmers to

be the owner. Older farmers still lack motivation to change their behavior to reduce burning because of the familiarity.

Therefore, changing the burning behavior of the farmer is not easy to do or accelerate in a short time. Because most of them are small-scale farmers which require the main labor and they have little income. Adopting large-scale machinery technology may need to arrange compensate for the different because burning is one of the production costs so it must be promoted gradually while concurrent penalties may be







## **Good Practices**

### **on Management and reduction of open burning in cultivated areas**

imposed. If the open burning can be effectively managed in cultivated areas,  $PM_{2.5}$  problems will be greatly reduced.

Agricultural waste from major cash crops such as rice, sugarcane, and corn, almost all of these are ecologically beneficial if they are managed and utilized properly. Currently, there are farmers who



are interested and various agencies that have adopted techniques and management to initiate action until it is a good practice to help reduce burning in farmland.

The good practices in disposing agricultural by products include plowing rice stubbles and straws to naturally fertilize soil, compressing straws for selling as animal feed, using the straws and stubbles as substrates for mushroom farming, adding supplements to straws

used for animal feeds, using compressed straws as materials in manufacturing furniture, using compressed sugar leaves as fuel for power generation in sugar factories, using sugar leaves to naturally fertilize soil and as soil cover, plowing corn stems, cobs and leaves to facilitate natural composting, composting corncobs to reduce fertilizer cost in following seasons and adding supplements to compressed leaves used for animal feeds.



## Management and utilization of agricultural waste

### **Rice:** **Straws and stubbles**



Plowing rice stubbles to naturally fertilize soil.

Adding supplements to compressed straws and selling them as animal feeds.

Making available compressed straws to increase better price.

Using straws and stubbles as substrates for straw mushroom farming.

Using compressed straws and stubbles in manufacturing furniture.

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### **Sugarcane:** **Stems and leaves**



Using compressed sugar leaves as fuel for power generation in sugar factories.

Chopping and mixing sugarcane leaves to use as natural fertilizer.

Using sugar leaves as soil cover to increase moisture.

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### **Maize:** **Stems, cobs and leaves**



Adding supplements to compressed leaves used for animal feeds.

Composting corncobs to reduce fertilizer cost in following seasons.

Plowing stems, cobs and leaves to facilitate natural composting.

Using compressed stems, cobs and leaves as fuels for biomass energy generation.



From studying and collecting data on practices for managing and reducing burns in farmland, it was found that the integration of cooperation between the public, private sectors, educational institutions, farmers, and the public has been initiated and implemented to support and encourage the control, supervision and reduction of open burning from the source as a best practice. Thus, participation in maintaining air quality to be within the standard and reducing the impact on people's health must be expanded more broadly in the future. Examples of practices for managing and reducing burns in farmland are as follows:

**1) Organic fertilizer bank: a source of farmers' additional income**  
at Bann Yang Tai Village, Si Satchanalai District, Sukhothai Province

An organic fertilizer bank was established by a group of farmers at Ban Yang Tai Village. They use agricultural waste to produce organic fertilizer to reduce cultivation costs and increase income. This is a model and learning source for study visits in the production of organic fertilizers.

Currently, the bank has more than 50 members. They are alert to deposit leftover rice straw at the bank and withdraw it as fertilizer and bio-fertilizer to use in their farms. This practice can reduce the use of chemicals and reduces costs considerably. Upgrading to a model and expanding the organic fertilizer production network for nearby communities which greatly reduces the burning of rice straw. (Siamrath Online, 2019)



## 2) Agricultural Learning Center : Promote the cessation of the burning of agricultural materials in Nakhon Nayok Province



Farmers in Nakhon Nayok Province grow rice in relatively deep paddy-fields and often burn their lands before cultivation. Such practice results in soil degradation, loss of nutrients and increase soil temperature and eventually make ecosystems less accommodating to cultivation.

Technologies were therefore introduced to reduce burning in 4 districts of the province including by establishing demonstration plots on farming management, expanding efforts to utilize and add value to agricultural byproducts, building networks of demonstration plot owners, making available compressed straws for animal feeds and enabling production of organic compost. Farmers have been found to be satisfied with the initiative and voluntarily joined the efforts to phase-out burning of agricultural byproducts, resulting in direct and indirect benefits to farmers, more replenishment of soil nutrient and improvement in agricultural ecosystems (Technologychaoban, 2020).

**3) Mae Chaem Model Plus for reducing the burning area and increasing forestlands** at Ban Thap Sub-district, Mae Chaem District, Chiang Mai Province



Smog from forest fire in Northern Thailand is a chronic problem that occurs annually by burning in farmlands and is affecting the climate and public health.

Therefore, a Memorandum of Understanding (MOU) was signed in 2016 to

enable sustainable cooperation of efforts to address problems of smog and forest fire. Mae Chaem Model Plus is a pilot project initiated under the MOU in 14 villages of Mae Chaem District and includes implementation of a strategy for joint actions on utilization of forestlands, allocation of farmlands, reduction of smog, tackling debt problems and develop career and enhancing communities' capacity. The project has also contributed to reduction in maize farming and subsequently burning in the farmlands while increasing the income of the villagers (Community Organizations Development Institute, 2019).

**4) Utilizing byproducts from maize farms for cultivation of organic mushroom** at Ban San Rungrueang Community, Nam Muap Sub-district, Wiang Sa District, Nan Province

Most farmers at Ban San Rungrueang Community cultivate maize as a result, a large number of dispose corncobs and, smog pollutes the environment and is a risk of forest fire or the fire spreads to nearby communities.

Farmers therefore welcomed the use of corncobs as substrates for farming of straw mushrooms. Since cultivation of organic mushrooms is relatively simple and can get fast yield. The community is very interested because it is easy to do, non-toxic straw mushrooms can produce fast yields, thus expanding to neighboring households, raising the level of group activities and developing leadership potential. They organize a learning area to make use of corn husks to grow straw mushrooms in baskets and greenhouses (Creativity and Innovation Office, 2016).





**5) Turn corn husks into non-toxic straw mushrooms,**  
in Nan Province



The Department of Agricultural Extension has actively promoted and created value for farms to be environmentally sustainable by managing agricultural waste to benefit the community, reducing smog and create an ecological balance with the Community Fertilizer Soil Management Center.

Turning waste materials into value by 1) providing knowledge on fertilizers and their production; 2) managing agricultural waste such as plowing the stubble and producing compost, making bio-fermented water used in animal feed production, mushroom cultivation, crops and transform into table, chairs, paper, brooms and straw and use them as alternative energy such as smokeless bio charcoal furnace; and connect to market that buy agricultural materials such as a community rice center that buys compost, a tree shop that buys soil for planting and farmers who grow vegetables to buy manure.

## 6) Rolled sugarcane leaves instead of burning

at Mae Ku Sub-district, Mae Sot District, Tak Province

Burning-free communities in Mae Ku Sub-district of Mae Sot District in Tak Province, together with sugarcane farmers, aim to carry out sustainable awareness-raising activities to stop burning in agricultural areas.

For each 1,600 square meters of farmland, rolls of compressed sugar leaves could weigh around 1.5-1 tons and each ton of the compressed leaves can earn between 1,000-800 baht. The remaining leaves are plowed to naturally fertilize the soil for the next production season (Department of Agriculture Extension, 2016). Comparing the non-burning process to using a machine to help compress sugarcane leaf scraps for sale, it has been found that farmers can save on fertilizer costs. The soil is fertile, so there is no need to add fertilizer. In addition, there is also a joint management of machinery, which greatly reduced costs and expenses for farmers.



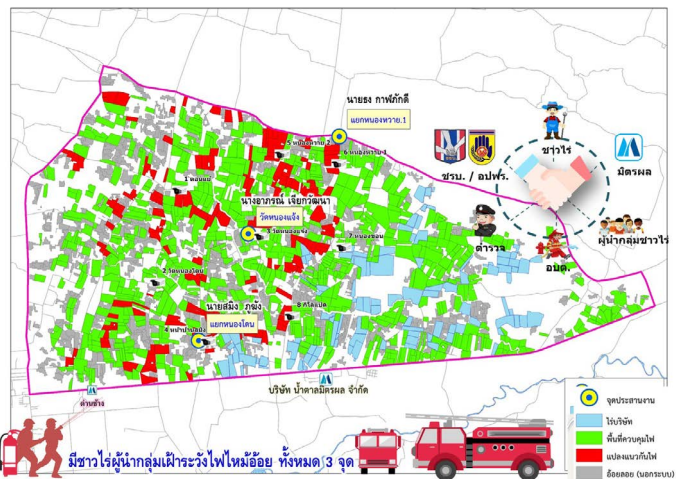
7) **Sugarcane bagasse fuel pellets** by Faculty of Engineering  
King Mongkut's University of Technology North Bangkok



Producing biomass fuel pellets from sugarcane waste with community participation by using a mobile biomass pellet machine into the sugarcane fields which solves the problem of burning and reduces transportation costs in the long term. Moreover, this can create an alternative energy source for the industry and add value to agricultural waste. The factory buys sugarcane leaves at a price of 600-800 baht per ton, while biomass fuel pellets are priced at 3,000-3,500 baht per ton.

At present, the results of farmers, gatherings have been expanded, such as the farmers in Don Chedi District of Suphan Buri Province and Bo Phoi District of Kanchanaburi Province, they produce biomass fuel which greatly generate income and reduces pollution as well. (Thailand Science Research and Innovation, 2016)

8) **Mega Farm Enterprise** at Chaeng Ngam Sub-district, Nong Ya Sai District, Suphan Buri Province



A mega farm enterprise at Chaeng Ngam Sub-district was found in May 2019 and consists of 43 members who grow sugarcanes for factories on a total area of 229.12 hectares. The enterprise was established to solve the problems of high production costs, increase productivity and develop the potential of its members in the production of sugarcane mills.

In addition, they also work together to managed resources in the community in a cost-effective and sustainable way, especially soil and water, conduct marketing in the form of large-scale integration and reduce the sugarcane fire in the specified period according to the measures before the sugarcane factory can be opened. These are policies that are consistent with the government’s campaign to reduce sugarcane fire, prepare fire extinguishers, demonstrate how to use the tools, cut the sugarcane according to the specified plot, make fire protection lines and set up an emergency unit to prevent the spread of fire (Royal Irrigation Department, 2019).







## **Concept and principles**

### **The adoption of management and reduction of open burning in cultivated areas**

The concept of pollution management places an initial focus on treatment of pollutants before their discharge into the environment. The private and state sectors have participated in the control and monitoring of emissions. With the adoption of the “**polluter pay principle**” in combination with the production technology that does not cause any waste or produces the least waste. Including emphasis on **prevention of pollution rather than pollution treatment**, and during the year 1992, the concept of **sustainable development** was applied to operate, developed mechanisms and method to **prevent pollution throughout the product life cycle**.

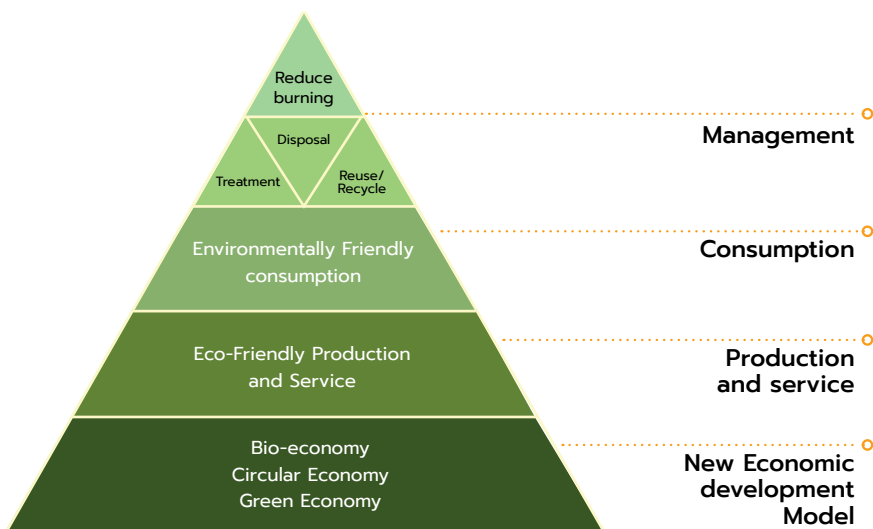
**Precautionary Principle** is used primarily in proactive management that focused on the prevention of early impacts and to strengthen the immune system of natural resources and the environment, especially in vulnerable areas. This is the way to prevent any impact that will occur, whether it is a risk or danger to health or the environment, and ultimately lead to the country's development goals.

In addition, to the above pollution management concept, it can be seen that the best pollution management is to **manage the source of pollution**. **Pollution management** by elimination and treatment methods is the management at the end of a cause which requires large budgets and is ineffective.

Thailand recently adopts a policy with emphasis on maximizing benefit and sustainability of biological resources while building capacity to compete in modern economy. The policy utilizes a new model for **economic development** (CBG Model) to attain equilibrium

between economic growth and sustainability of natural resources by adding value to biodiversity and conventional agricultural products with knowledge and innovation of **Bio-economy**, employing waste minimizing product design and manufacturing process of **Circular Economy** and utilizing environmentally sound production and consumption of **Green Economy**.

The management and reduction of burning in farmland in this document, therefore, adopts the principles, concept and policies mentioned above in order to maintain the stability and balance of the environment. It has been started by taking advantage of new economic development models, environmentally friendly production, service and consumption. In cultivation, when agricultural waste remains, it will be handled appropriately to minimize waste and burn only as necessary (as shown in the diagram)



Pollution management in the past had continued to focus on the elimination and treatment of pollution, despite efforts from many sectors to step up to prevent pollution at the source, both in the manufacturing sector, community and transportation sectors, etc.

However, the vast majority are still voluntary measures, resulting in pollution management only slowly moving towards preventative approaches, while the current situation of air pollution in Thailand is still on going.

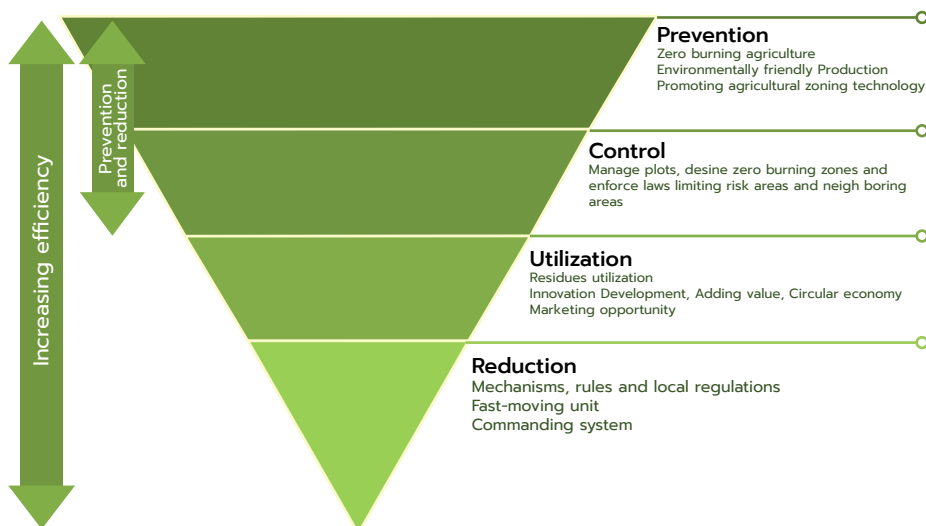


However, certain compulsory measures to prevent at the root cause are absolutely necessary. It will also require a variety of agricultural machinery technology tools, as well as a variety of restructuring and integrated working mechanisms to work together. In particular, the participation of farmers who are a large part of the social sector and remain a key factor in the achievement of the prevention of burning.

Therefore, the implementation of management and reduction of burning still requires a mechanism or tool to achieve real integration and participation from all sectors. From handling at the end of the cause to preventing it at the common source and there are significant long-term benefits to the manufacturing sector while reducing resource consumption and eliminating pollutants sustainably.

Applying principles of pollution management which address pollution prevention and control, utilization of byproducts and reduction of burning can provide guidance for comprehensive management of open burning in cultivated areas as an effort in addressing PM<sub>2.5</sub> problems as follow;

### Principles applied to manage and reduce burns in agricultural areas



**Burning prevention** burning-free farming must be promoted and supported by encouraging environmentally friendly production and providing technological supports in farming areas to accommodate field preparation and harvest.

**Burning control** open burning must be regulated with planning and notification requirements, reorganizing farmlands to accommodate use of machinery, designating areas where burning is prohibited, ensuring effective law enforcement as well as managing and eliminating risks from burning at particular sites and their adjacent areas.

**Maximizing effectiveness in utilizing agricultural byproducts** ensuring that every kind of farming materials can be used and reused including by developing innovations to add value to the materials, adopting circular economy concepts and providing markets for the materials.

**Burning can be reduced** by employing mechanisms at local level such as local provisions, rapid-response units for surveillance, monitoring and assessment and provincial centers for burning management to meet administrative requirements and issue necessary commands in timely manner.





## **Management guidelines and policy proposals**

### **Management of open burning in cultivated areas as an effort in addressing PM<sub>2.5</sub> problems in Thailand**

The guidelines for management and reduction of open burning in cultivated areas are based on the principles and concept of pollutions management at their sources. The guidance also aims to achieve sustainable management and development and contribute to formulation of policy advices on the issues





## Prevention and reduction of open burning in cultivated areas

**Enabling burning-free farming by adopting alternatives for management of agricultural byproducts and placing more emphasis** on maximizing utilization of the by products including by plowing straws, stubbles, leaves and other plant materials to fertilize soil, substituting chemical fertilizers with composts, covering soil with plant materials to increase moisture and using agricultural byproducts as animal feed and fuel materials.

**Developing technologies that provide alternatives in cultivation ranging from field preparation, harvest to transports of produces** in order to address both labor shortage and the need to reduce burning in farmlands. These may include introduction of machinery for plowing and harvest.





## Enhancing effectiveness in management and reduction of open burning in cultivated areas

- ① **Increasing appropriate incentives for farmers who avoid burning** on their lands by providing conditional subsidies because managing unburned farms costs more than the burnt farms.
- 📁 **Developing a database** to assess the risk and vulnerable farmlands that are the source of open burning and consider subsidizing farmers per hectare to compensate for the additional cost in case of not burning
- 🌿 **Promoting composting** in every area and providing compensation to farmers for additional cost associated with burning-free practices.
- 🏪 **Developing markets for agricultural byproducts** in order to add economic value to the materials in the manner that reflect their contribution to pollution mitigation.
- 🗑️ **Promoting markets for agricultural waste** in order to make this waste has potential and value in the economics of pollution.
- ⚙️ **Promoting rental markets of modern agricultural machinery** as well as to educate farmers to prepare the farmlands that are ready and suitable for using the machines.
- ☰ **Developing mechanisms and networks to address burning in cultivated areas in association with pre-existing local networks** in order to enable surveillance, monitoring and assessment of situations and pollutants' concentration and to develop agreements and incentive measures that are compatible to local production.



## Controlling management of open burning in cultivated areas

- 🚫 **Banning any burning near residential areas and strictly enforcing the ban** by setting up systems for timely reporting and for extinguishing fire and establishing agreements between farmers, buyers of agricultural products and relevant agencies on voluntary reduction of burning in cultivated areas.
- ☰ **If the burning is found to be necessary, planning will be made on cultivation and management of the burning in order to mitigate air pollution** by considering the capacity of handling air pollution and meteorological conditions with plans to support and inform the community.
- ⊞ **Organize the burning of agricultural waste** in order to reduce its density. Manage fuel before the season or burn it to reduce the amount of fuel in repetitive burning areas by registering, notifying and planning to gradually burn at the same time or burn during the open air and impose penalties for those who cause pollution.
- 🔪 **Ensuring effective law enforcement** including by linking geographical information systems with registration of farmers who received farming aids. Satellite imagery might be employed to identify burning and disqualify landowners from receiving government aids such as subsidizes and disaster reliefs when burning is found to have occurred on their lands.

# 13 The policy proposals on management of open burning in cultivated areas as an effort in addressing PM<sub>2.5</sub> problems in Thailand

The policy proposals on the management of open burning in agricultural areas have considered as a solution to the problem of PM<sub>2.5</sub>, using a combination of social concepts to modify the burning management practices, including waste utilization and the economics principles that affect costs and inputs. The proposals are as follows:

1



**Determine the target areas to achieve the burning reduction then develop an action plan to reduce the burning of cash crops that risk of burning** by considering the number of hotspots in relation to the air quality index in all areas such as rice, maize and plants that are more vulnerable of fire and together with the integration of work and clearly defining the roles and duties of the 4 main departments under the Ministry of Agriculture and cooperatives to set such goals.

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2



**Building awareness, knowledge and understanding on the problems associated with burning in cultivated areas, including their health impacts** by enabling wider communication of simple messages on the issues through vigorous campaigning and public relations in order to stimulate greater adoption of environmentally sound behaviors. The actions can be carried out in association with the Ministry of Natural Resources and Environment and the Public Relations Department.

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# 3



## **Conducting innovation study and research on the use of agricultural waste**

to increase the economic value of all types of agricultural materials throughout the supply chain for optimal benefits and efficiency across all crop types. For example, making biomass energy or other products and promoting the market to support that product.

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# 4



## **Establishing meta databases (Big Data) on agriculture**

to interactively integrate various information including those derived from geographical information systems such as land use, water reservoirs, climate, natural disasters, and other important areas for agriculture. This effort could build on the pre-existing Agri-Map and can be used to enable spatial management of cultivation and opening burning in farmlands.

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# 5



## **Enabling inclusions of efforts to avoid burning in rice, sugar and maize farms and other cultivate areas with fire risk as an additional element in good agricultural practices (GAP)**

and providing certificates to products that derived from farmers who follow such practices.

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# 6



## **Rising income guarantee payments to farmers who avoid burning byproducts on their farms,**

particularly for rice cultivation in farming season and maize cultivation. Efforts could be made to widen the gap of the payments between farmers who practice and do not practice burning on their lands and set up a fee for the burning in order to provide incentives for farmers to phase-out the burning.

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# 7



**Increasing the utilization and commercialization of all types of agricultural waste** to ensure circulation throughout the supply chain to meet environmentally friendly agricultural production and support Start-ups that focus on agricultural waste.

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# 8



**Developing incentive measures and providing conditional financial aids for farmers** to acquire necessary inputs for phasing-out the burning including procurement of farming machinery and building competitive markets for agricultural byproducts in order to ensure attractive buying prices and greater disincentive for the burning.

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# 9



**Promote cooperation in the management of agricultural inputs that facilitate the management and reduction of burns in farmland**, such as water resources, water management, a variety of agricultural equipment and tools in a form of local circular sharing to meet the needs and management according to the context of each area.

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# 10



**Developing Public-Private-People Partnership (4P) and pursuing adoption of Circular Economy** to add value to farming byproducts, enable their reuse and recycle, minimize waste disposal and improve environmental conditions.

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# 11



**Promote market mechanisms** by increasing production standards of non-burning agricultural production to be environmentally friendly agriculture with high value and safe from contamination problems.

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# 12



**Integration of work between the agricultural, industrial, energy and local sectors** as well as appointing the main host authority to control and supervise cultivation of economic crops that affect open burning and the risk of air pollution, including the entire production system to achieve good practical results.

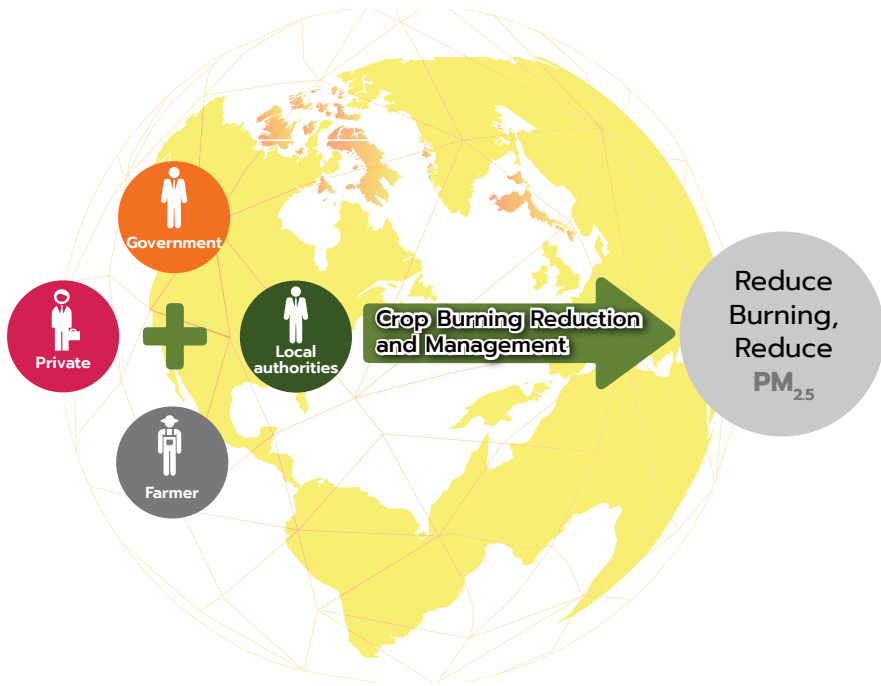
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# 13



**Accelerate the allocation of land and necessary infrastructure** for agriculture to the community, such as, roads, water sources and so on. In an effort to support integrated planting instead of monocultures that rely on rainwater and natural water, as well as the burning to prepare area for the next growing season.

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*“ Thai farmers join hands to  
manage and reduce burning and solve  
the problem of PM<sub>2.5</sub> ”*