RPF - III

PROFORMA FOR SUBMISSION OF ANNUAL PROGRESS REPORT OF RESEARCH PROJECTS

Part - I: GENERAL INFORMATION

800 Project Code :
8001 Institute Project Code No. :
8002 ICAR Project Code No. :

801 Name of the Institute and Division:
8011 Name and address of Institute: : Indian Institute of Spices Research, Calicut
8012 Name of Division/Section : Crop Production and Post Harvest Technology
8013 Location of Project : Indian Institute of Spices Research, Calicut
802 Project Title **: Climate change effects on growth and productivity of black pepper; Impact, adaptation and vulnerability, and mitigation strategies**
803 Priority Area :
8031 Research Approach :

Applied Research	Basic Research	Process/Technology development	Transfer of Technology
01*	02*	03	04

804 **Specific area** : Climate change effects
805 **Duration of Project** : 3 years
8051 Date of start : December 2004
8052 Date of completion : March 2007
806 **Total cost /Expenditure Incurred** : Rs 11.45 lakhs

807 Executive Summary

Trend analysis of the past climate data indicated that in general, total rainfall is showing a decreasing trend while Tmax and Tmin are increasing in most of the black pepper growing areas. Black pepper productivity is also showing a decreasing trend. In general, December and January rainfall showed negative correlation with productivity indicating that more rainfall during this period may affect productivity. In general, April-May rainfall had positive influence in productivity. Rainfall during October rainfall showed positive correlation with

productivity in Pampadumpara while in Wynad, July rainfall showed positive correlation. There seem to be no significant difference in growth parameters of black pepper varieties grown at normal and elevated temperatures though some fluctuations were noticed for all the parameters studied including photosynthesis. Quality parameters of black pepper grown under higher elevation showed difference from those grown under low elevation.

PART - II: INVESTIGATOR PROFILE

(Please identify clearly changes, if any in project personnel)

810 Co-Principal Investigator :

8101	Name	: Dr K.S. Krishnamurthy
8102	Designation	: Senior scientist (Plant Physiology)
8103	Division/Section	: Division of Crop Production and Post Harvest Technology
8104	Location	: Indian Institute of Spices Research, Calicut
8105	Institute Address	: Indian Institute of Spices Research, Calicut

811 Co-Investigator

8111	Name	: Dr K. Kandiannan
8112	Designation	: Senior scientist (Agronomy)
8113	Division/Section	: Division of Crop Production and Post Harvest Technology
8114	Location	: Indian Institute of Spices Research, CRC, Appangala
8115	Institute Address	: Indian Institute of Spices Research, Calicut

812 Co-Investigator

8121	Name	: Dr B. Chempakam
8122	Designation	: Principal Scientist and Head,
8123	Division/Section	: Division of Crop improvement and biotechnology
8124	Location	: Indian Institute of Spices Research, Calicut
8125	Institute Address	: Indian Institute of Spices Research, Calicut

PART - III: TECHNICAL DETAILS

820 Introduction and Objectives:

8201 Project objectives :

National status:

To study the climate change during past decades in agro climatic zones where black pepper is grown

To study the impact of climate change on the productivity of black pepper in different agro climatic regions

To study the impact of elevated temperature and CO_2 on growth of black pepper

To investigate the effect of temperature on quality parameters of black pepper

To identify the areas that are more prone to climate change related risks such as floods, drought, high temperature etc. for disaster management from plantation sector point of view.

821 Project Technical Profile

8211 Technical Programme

(Indicate briefly plan of procedure, techniques, instruments and special materials, organisms, special environments etc.)

Methodology:

Objective 1: Climate data viz, rainfall, maximum and minimum temperature and Relative humidity data for the past 2-3 decades was collected from different black pepper growing regions and was subjected to trend analysis.

Objective 2: Black pepper productivity data for the same period (past 2-3 decades) was also collected from different black pepper growing regions and similar analysis was done. Correlation was worked out between black pepper productivity and different climatic parameters to study their influence on productivity.

Objective 3: Seedlings of different black pepper varieties were maintained in growth chamber at ambient day/night temperature levels as well as the temperature levels predicted for 2050 for this region as per HadCM3 model (A2a scenario) and the difference in growth and photosynthesis were assessed to study the effect of elevated temperature as projected for 2050.

Objective 4: Quality parameters viz., oil, oleoresin and piperine and other quality measures such as grade, bulk density, starch, fibre etc. were analysed in samples collected from different agroclimatic regions and the places having the same climate except for temperature were compared to study the effect of temperature on quality. Piperine was quantified through HPLC, oil was extracted through hydrodistillation and oil components were analysed through GLC. Starch was estimated using anthrone method and fibre through fibre tech apparatus.

8212 Total man months involvement of component project workers

K.S. Krishnamurthy	4
K. Kandiannan	5
B. Chempakam	4

Total

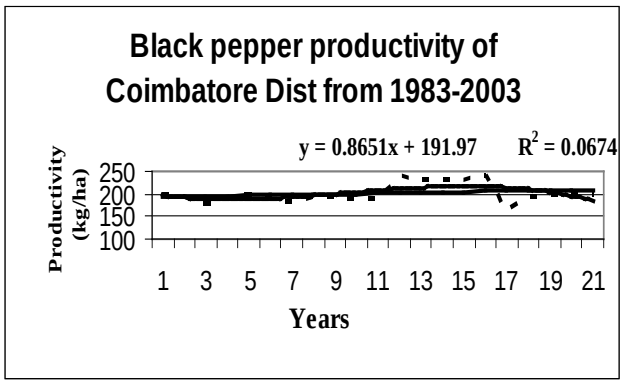
822 Final Report on the Project

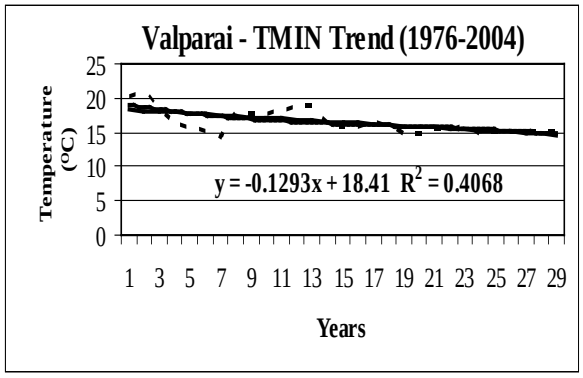
Detailed report containing all relevant data with a summary of results (not exceeding 2-5 pages)

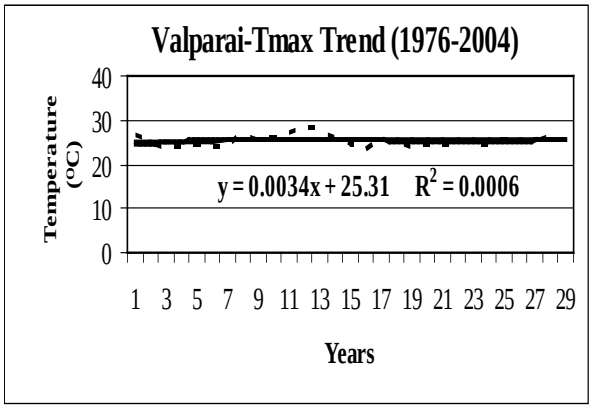
Progress of work

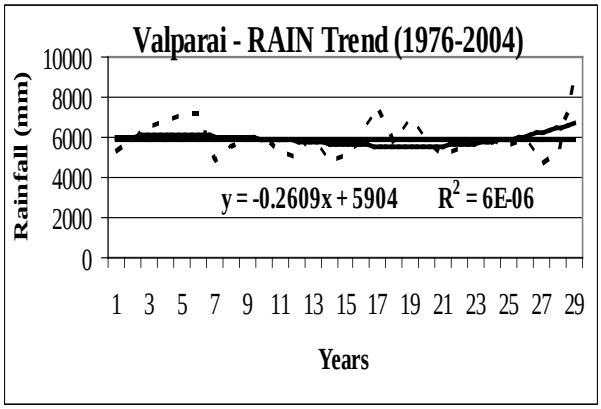
Trends in past climate and productivity

Trend analysis for the past changes in climate of pepper growing areas such as Wynad (Ambalawayal), Calicut, Cannanore (Panniyur), Idukki (Pampadumpara), Coimbatore, Nilgiris and Coorg has been done. Black pepper productivity trend analysis for most of these places has been done. A few sample graphs are given below.









As shown above, the data on rain fall, Tmax and Tmin were collected from major black pepper growing areas of Kerala, Karnataka and Tamilnadu for the past two decades (1984-2004). The black pepper productivity data was also collected for the corresponding period from these regions. In general rainfall and productivity showed decreasing trend while Tmax and Tmin showed decreasing trend. The summary table is given below.

Place	Rain fall	Tmax	Tmin	Productivity
KERALA				
Wynad	Decreasing	Increasing	Increasing	Decreasing
Calicut	Decreasing	-	-	Decreasing
Cannanore	Decreasing	Increasing	Increasing	Decreasing
Tamil Nadu				
Valparai	No trend	No trend	Decreasing	No trend
Nilgiris	Increasing	Increasing	No trend	Decreasing
Karnataka				
Coorg	Decreasing	-	-	Decreasing

Correlation between past climate and productivity

Ambalavayal

The correlation between black pepper yield and climate parameters was worked out. In Ambalavayal (Wynad) December rainfall showed negative correlation with productivity. Tmin during March and January showed significant positive correlation with productivity while Tmax did not show significant correlation. The relation between productivity, and rainfall and temperature during various months is given below.

Nilgiris

In Nilgiris, Rainfall during December and January had negative correlation with black pepper productivity. Number of rainy days during May had positive influence while that of January was negatively correlated. Though Tmax was positively correlated with production in most of the months, the correlation was non-significant. Tmin showed significant positive correlation with pepper productivity during March, April, July, August and October months.

Pampadumpara

In Pampadumpara (Idukki Dist., Kerala) October rainfall was positively correlated while June, July & September had negative influence on productivity.

Panniyur

Here also, rainfall and Tmax during December showed negative correlation with productivity while rainfall during other months did not show significant correlation. Tmin from August to December also showed significant negative correlation with productivity

Trichur

Rrainfall had no significant influence on productivity. Tmin during January and Tmax during May and July had significant negative influence on productivity.

Valparai

None of the climatic parameters showed significant correlation with productivity in any of the months.

The correlation between climatic parameters and productivity shows in general that in plains Tmin and Tmax are generally negatively correlated while in higher elevations, Tmin is positively correlated with productivity. Tmax does not any influence with productivity in higher elevations. This implies that climate change especially the increase in temperature may have positive influence on productivity in higher elevations while the same may have negative influence in plains. December, and January rainfall in certain cases is negatively correlated with productivity.

Normalised yield deviations (NYD) have been worked out for different stations. This was regressed with rainfall, Tmax and Tmin to get regression line which can predict the yield deviations if values for rainfall, Tmax and Tmin are substituted in the equation. The equation for Coimbatore is

Y = (0.18433+(0.0000158X1)-(0.01354X2)+(0.006263X3)

Where **Y** = yield, X1 = rainfall, X2 = Tmax and X3 = Tmin

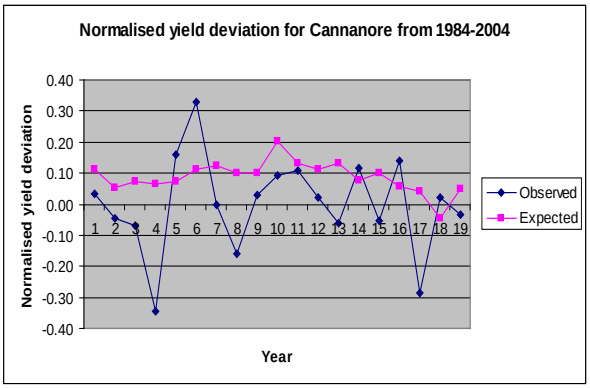
Based on the above equation, NYD has been predicted using HadCM3 RCM predictions for 2020, 2050 and 2080 for the grid covering Valparai for A2a scenario which is given. The actual station values for the year 1980 were used as base values.

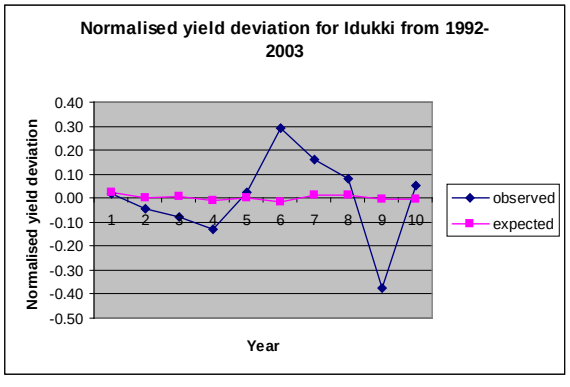
Year	Rainfall (mm)	Tmax ^{0}C	Tmin ^{0}C	NYD
2020	5181	25.5	16.6	0.0252
2050	5182	26.4	17.5	0.0183
2080	5184	27.4	18.5	0.0108

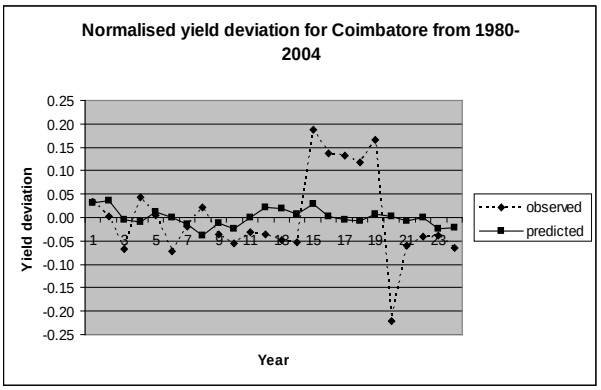
Wynad

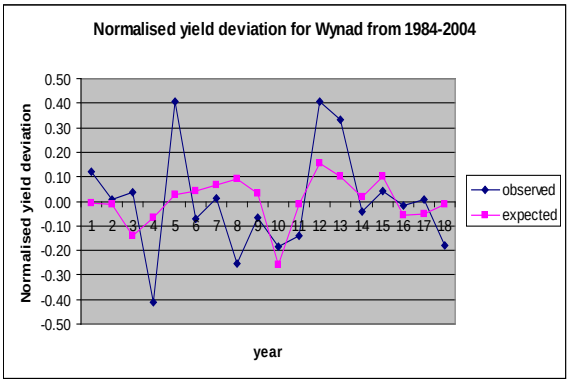
Year	Rainfall (mm)	Tmax ^{0}C	Tmin ^{0}C	NYD
2020	2605	31.70	20.82	0.1932
2050	2600	32.63	21.74	0.2221
2080	2592	33.59	22.68	0.2512

Similarly, normalized yield deviations have been worked out for different black pepper growing areas of Kerala, Karnataka and Tamilnadu. For coimbatore, rainfall, Tmax and Tmin all showed increasing trend with future climate projections while the productivity does not seem to vary much from the present values as indicated by normalized yield deviations. For Wynad, future climate prediction shows a slight reduction in rainfall while both Tmax and Tmin show decreasing trend and the productivity prediction shows an upward trend of about 20 % from the present values. The same has been represented graphically for a few places.









Normalised yield deviations of different estates of Coorg (1995-2002)

Yield deviations are positive for certain estates while some other estates show negative yield deviation . Expected yield deviations are negative for most of the estates while observed shows lot of variation making future predictions shaky based on previous climate.

Regression equation for different estates of Coorg based on rainy days, rainfall, Tmax and Tmin from 1995-2005

The regression equation shows that Tmax and Tmin may have more influence on productivity than rainfall or rainy days. Also it is generally true especially in estates that rainfall and rainy days may not have much influence as the crop is mostly irrigated. Tmax and Tmin are showing negative influence which indicates that climate change in terms of increase in Tmax and Tmin may have negative influence on productivity.

Correlation between previous year's rainfall and pepper production.

Since black pepper is a perennial crop, previous year's rainfall may have some effect on the productivity during the present year. To investigate such effects, the correation between the previous year's rainfall with the present year productivity was worked out in different plantations for ten years from 1996 to 2005. Surprisingly, in most of the plantations studied, the correlation was negative.

Influence of rainfall deficit on black pepper productivity was also studied. Rainfall during 1987 and 2002 (declared as drought years by the government) was less than normal (mean of 1984-04) for all the black pepper growing areas during those years. The black productivity also was below normal (mean of 1984-04) for those years indicating the negative influence on rainfall deficit on black pepper productivity.

Pepper productivity is generally higher in higher elevations such as Wynad and Idukki. Relatively cool climate of these regions may have influence on productivity. From the table given below, it is clear that the temperature (both Tmax and Tmin) of both Idukki and Wynad is about 6-7 degree lesser than that of Cannanore or Trichur.

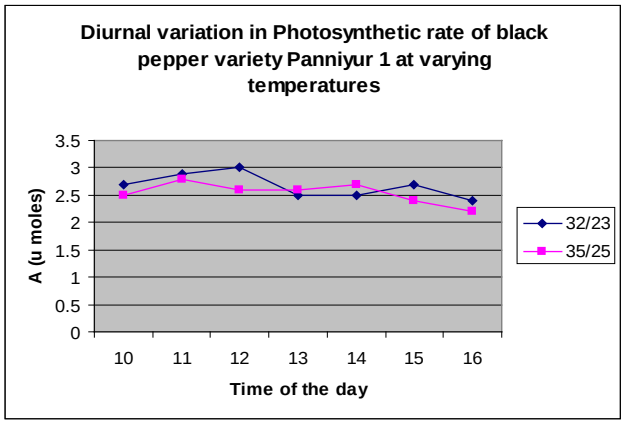
Response of black pepper to increased temperature

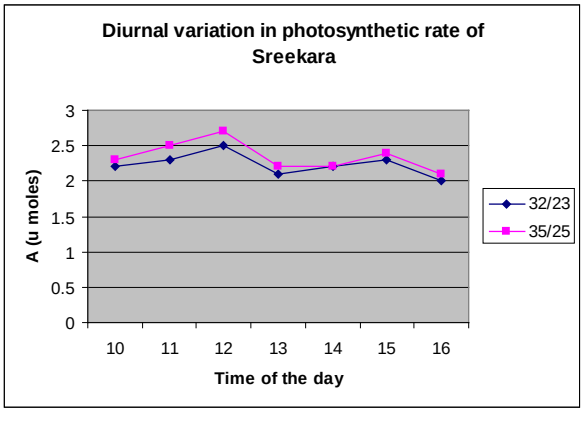
Based on HadCM3 RCM predictions for 2020 and 2050 for the grid covering Calicut for A2a scenario, the increase in Tmax for Calicut is about 1.7 degrees for 2020 and 2.7 degrees for 2050. Similarly, increase in T min is about 0.5 and 1.5 degrees respectively. Based on this, an experiment was set up in black pepper with 10 varieties in growth chamber with set temperatures of 2.7 and 2 degrees increase (over 20 years average) in day and night temperatures respectively. Growth parameters (plant height and leaf area at regular intervals) and diurnal variation in photosynthetic rate was measured and compared with those of present ambient conditions.

There was not much variation in growth parameters of black pepper grown at elevated temperatures. The percentage variation was less than 10 for both leaf area as well as plant height after 4 months of growth at elevated temperatures. Varietal variation was noticed for both plant height and leaf area but the mean values for both did not alter much.

Diurnal variation in photosynthesis

Diurnal variation in photosynthesis varied with the varieties but there was very little deviation in diurnal variation between plants grown at normal and elevated temperatures indicating that elevated temperatures of 2-3 degrees may not have much impact on the growth of black pepper.





Influence of temperature on Quality parameters

To study the influence of climate (mainly temperature) on quality parameters of black pepper, black pepper berries were collected from about 95 locations covering major black pepper growing regions of Kerala, Karnataka and Tamilnadu. The mean temperatures (Tmax) of different coastal districts of Kerala vary from 31-34 degrees. The HadCM3 model (A2a Scenario) predicts about 3 degree increase in temperature for Kerala by 2050. Hence, if we study the quality changes in different coastal and low elevation districts, it may give an idea about the quality changes due to 2-3 degree increase in temperature. The table given below depicts the sample values of quality parameters of black pepper such as oil, oleoresin and piperine in a few districts of Kerala, Karnataka and Tamilnadu. Though there is variation in oil, oleoresin and piperine content of samples from different places, temperature does not seem to play major role. For example, the oil content of Kasaragod, Calicut, Kottayam, Aleppey and Trivandrum, all samples are around 3.0 %. Similarly piperine content for these places is around 4.0 %. But samples from higher elevation (Wynad and Idukki) showed slightly lower oil and piperine content. Karnataka and Tamilnadu samples had lesser oil and piperine content than Kerala samples and mostly, these are under higher elevation. The data from different locations is given below.

Essential oil components

The essential oil components also were studied using Gas liquid chromatography (GLC). These components are the ones which give characteristic flavour. Again, there was no variation in essential oil components among coastal districts of Kerala. But in general, Sabinine+myrcine was noticed in samples from higher elevation but occasionally noticed in samples from lower elevation. Beta caryophyllene was low and limonene was high in samples from higher elevation. The data of the essential oil components from different places is given below.

Physical quality

The physical quality parameters such as bulk density, test weight, berry starch, berry protein and crude fibre were also analysed in all the 95 samples collected. Grading of the samples was also done. There is lot of variation among the samples for all the parameters and it appears that climate in

terms of elevation of a place has some influence on the physical quality also. The data needs to be analysed critically and also statistically before drawing any conclusions.

Physical quality parameters such as test weight and bulk density and biochemical quality parameters viz., starch, fibre and protein contents also did not show any variation with respect to temperature of places though there was difference among the places for these parameters.

8221 Achievements in terms of targets fixed for each activity

All the targets could be fulfilled except the response to elevated temperature and CO_2 as the facility i.e., open top chamber establishment at CPCRI got delayed due to technical snag.

8222 Questions - Answered:

Influence of past climate on black pepper productivity

Growth of black pepper grown at elevated temperatures

Quality as affected by climate

8223 Process/Product/Technology/Developed:

8224 Practical Utility

(not more than 150 words)

The results of the study suggest that climate change (increased CO_2, Tmax , Tmin, and decreased rainfall may affect black pepper production and hence varieties suited to such changes can be used in areas where the climate change is more obvious. This also helps in exploring newer areas for black pepper cultivation depending on the past climate and the extent of climate change during the past decades.

8225 Constraints, if any

823 Publications and Materials Development:

(One copy each to be supplied with this proforma)

8231 Research papers: To be published (Manuscript is being prepared)

1. Climate change and its influence on productivity in different black pepper growing areas of the country (K.S. Krishnamurthy, K. Kandiannan, B. Chempakam , A. Suresh and C. Sibin). Communicated to Indian J. of Agric. Sciences.

2. Climate change effects on growth and photosynthesis of black pepper seedlings (K.S.

Krishnamurthy, K. Kandiannan, B. Chempakam and A. Suresh)

3. Climate change and black pepper quality (K.S. Krishnamurthy, B. Chempakam, T. John Zachariah, K. Kandiannan , V. Sapna, and A. Suresh)

8232 Popular articles : _

8233 Reports

8234 Seminars, conferences and workshops (relevant to the project) in which the scientists have participated. (List abstracts forwarded)

First annual workshop at CRIDA, Hyderabad during 2004
Second annual workshop at CPCRI, Kasaragod during 2005
Third annual workshop at NDRI, Karnal during 2006

824 Infrastructural facilities developed:

(Details of field, laboratory, note books and final material and their location)
Field note books and data registers are available in the Division of Crop Production and PHT in the center.

825 Commments/suggestions of Project Leader regarding possible future line of work that may be taken up arising out of this Project.

Response of black pepper to elevated carbon dioxide and temperature and identification of varieties which respond to both increase in temperature as well as carbon dioxide together as both are expected to rise due to global warming. Quality changes with respect to conrolled environmental studies is also needed.

PART - IV PROJECT EXPENDITURE (Summary)

830 Total Recurring Expenditure

8301 Salaries: (Designation with pay scale)

Actual

i)	Scientific	:
ii)	Technical	: 181676
iii)	Supporting	:
iv)	Wages :	
	Sub Total	: 181676

8302	Consumables	
	i) Chemicals	: 300000
	ii) Glasswares	:
	iii) Others :	
	Sub Total	: 300000
8303	Travel	: 35000
8304	Miscellaneous (other costs)	:
8305	Sub-Total (Recurring)	: 335000
831	Total Non-Recurring Expenditure (Equipments and works)	400000
	Sub total	: 400000
832	Total (830 and 831)	**916676 + 104324** (refunded)

PART-V: DECLARATION

This is to certify that the final report of the Project has been submitted in full consultation with the Project workers as per the approved objectives and technical programme and the relevant records, note-books, materials are available for the same.

Signature of the Project Investigator

Co-investigators 1.

2.

Signature and comments of the Head of the center :

Signature and comments of the Head of the Division :

Signature and comments of the Director :